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## USER'S MANUAL FOR ESTIMATING TARGET ACQUISITION RANGE WHEN EMPLOYING TV SENSORS

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## DECEMBER 1983

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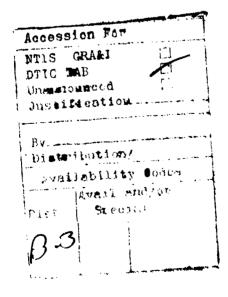
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## USER'S MANUAL FOR ESTIMATING TARGET ACQUISITION RANGE WHEN EMPLOYING TV SENSORS

## INTRODUCTION

This technical note has been designed to provide AWS personnel with the capability to give environmental support to customers who use acquisition or tracking systems that employ TV sensors. The forecast techniques provided in this text should be used only if the TV-Tactical Decision Aid is not available. The manual method described herein can be used to estimate the maximum acquisition ground range from TV sensor to target. User inputs have been kept to a minimum and include only basic mission and forecast variables. The User's Guide section is preceeded by a section on TV sensor background material which, hopefully, will provide the user with the necessary "feel" to use this publication with confidence.





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## TV SENSOR BACKGROUND MATERIAL

There are many kinds of electro-optical (E-O) sensors. They may be classed according to their electromagnetic wavelength sensitivities, i.e., TV (0.4 to 0.7 micrometers), near IR (0.8 to 2.0 micrometers), middle IR (2.0 to 5.0 micrometers), and far IR (5.0 to 13.0 micrometers). They may also be classed according to their method of operation, i.e., active (has its own radiation source), semi-active (senses emissions from an articificial source of radiation), or passive (senses radiation emitted by a natural source). Finally, they may be classed according to their function, i.e., target search, detection, lock-on, tracking, or evaluation. Our focus will be on passive TV sensors that may be used in multiple roles but will primarily be used for detection and/or lock-on.

The operational use and limitations of TV sensors are relatively easy to appreciate in contrast to infrared sensors. This is due to the fact that TV sensors respond to visible light in much the same way as our eyes (biological E-O sensors). However, given equal optics (light gathering device) the eye still has greater ability to distinguish the contrast or difference between an object and its background.

The question of interest to us is "At what distance can our TV sensor 'see' an object against its background?" Quantitatively, we assess whether or not a TV sensor can be used based on predictions of target/background contrast received at the sensor position. The problem involves both the specific scene and the visible image transmission (in terms of target/background contrast) through the atmosphere. Three important categories of visual contrast are: inherent contrast, apparent contrast, and threshold contrast.

Inherent contrast  $(C_0)$  is the visual contrast that exists between the object (in our case target) and its background at zero range. Its value ranges from 0 to 1. It is given in terms of the difference between the target and background luminances (brightness) divided by the larger of the two luminances. For target scenes made visible solely by reflected light, target and background reflectances can be substituted for luminances. Thus, for passive TV sensors:

$$C_o = |R_t - R_b| / R_{max}$$
 (1-1)

where  $R_t$  is the target reflectance,  $R_b$  is the background reflectance, and  $R_{max}$  is larger of  $R_t$  and  $R_b$ .

The visual contrast we see at some distance from the object/background is called the apparent contrast  $(C_r)$ . The atmosphere acts as a contrast-degrading medium causing  $C_r$  to decrease as the range increases. The deceivingly simple equation for apparent contrast:

$$C_r = C_o \times T_c \tag{1-2}$$

where  $\mathbf{C}_0$  has been defined above and  $\mathbf{T}_c$  is the contrast transmission (a very involved quantity).

The algorithms used to compute the TV contrast transmittance curves contained in the Appendix H were developed at the Rand Corporation. They were first used as part of the WETTA (Weather Effects on Tactical Target Acquisition) model. The "transmittance" is a complicated function of many environmental

factors including the relative positions of the sun, sensor, and target. Technically, the word transmittance refers to radiation removed by the extinction processes of scattering and absorption. During the transfer of visible contrast through the atmosphere, however, the primary degradation process is the scattering of light into the field of view. Nevertheless, we will still use the term "contrast transmittance."

The model computes contrast transmittance as a function of the range from the sensor to the target, the "sky-ground ratio parameter," and the atmospheric extinction coefficient for visible light. The extinction coefficient is calculated as a straightforward function of the reported visibility, using Koschmieder visibility theory. The sky-ground ratio is the ratio of the luminance of the horizonal sky to the inherent luminance of the target's background, with reference to a given viewing geometry. In practice, sky-ground ratio is seldom measured.

Sky-ground ratio is computed as an extremely complicated function of four variables: the background reflectance  $(R_{\rm b})$ , sometimes called ground albedo; two angles (the dive angle and the elevation angle of the sun); and the visibility (from which the atmospheric extinction coefficient is estimated). Sky-ground ratio has the following general characteristics. It increases with decreasing albedo, or decreasing visibility, or decreasing sum angle. It is independent of sum angle under cloudy skies. It is nearly independent of sum azimuth angle, and it is largest when the dive angle is 10-30 degrees.

Finally, the last type of visual contrast concerning us is the threshold contrast  $(C_{TA})$ . It is that particular target-to-background apparent contrast at which 50 percent of observers will detect the target and 50 percent will not. For the human eye, the contrast threshold is approximately 0.02, and it is primarily a function of the size of the object seen in the field of view and the time spent looking at it. Each TV sensor will have its own threshold contrast which has been determined experimentally. A typical value of  $C_{TA}$  is 0.2. This value of  $C_{TA}$  along with  $C_0$  is critical to our calculations of target acquisition range.

If we take equation 1-2 and replace apparent contrast  $(C_r)$  with threshold contrast  $(C_{TA})$ , then divide both sides by inherent contrast  $(C_0)$ , we calculate a special value of contrast transmission  $(T_c)$ , a value called threshold contrast transmittance (C'). This value is the simple ratio of  $C_{TA}$  to  $C_0$ :

$$C' = C_{TA}/C_0 \tag{1-3}$$

If for instance, our inherent contrast  $(C_0)$  is 1 (a white on black target) the value of C' and  $C_{TA}$  are equal (say 0.2). However, if  $C_0$  is 0.5, then C' (0.4) is twice as large as  $C_{TA}$  (0.2). By writing equation 1-2 in this ratio form we are able to make transmittance charts that are useful for all combinations of target/backgrounds and TV sensors.

The charts in Appendix H contain plotted isopleths of C' (in tenths) given by range and altitude. By locating the appropriate C' at the given flight altitude, one can easily estimate the maximum target acquisition range. This value is the maximum acquisition range because the threshold contrast (the smallest one detectable) was used to calculate C'. Furthermore, the range is only valid for the target/background specified. Different inherent contrasts and, consequently, different C's would have to be calculated for other scenarios.

There are many assumptions, and thus limitations, in this method that the user of this publication should be aware of. First, the model assumes a two-layer atmosphere, the boundary of which is defined by the height of the surface mixing depth. Below this height the extinction coefficient is calculated from the surface visibility and is assumed constant through the layer. Above this height the extinction coefficient is set to a constant value representative of good visibility. Studies have shown that this type model is a good approximation to the real atmosphere in most, but not all, cases.

Secondly, basing extinction coefficient estimates on visibilities (visual range), probably the least objective of all observed or forecasted weather values, limits the accuracy of the model. Not only are visibilities difficult to forecast, there is no exact relationship between them and visual extinction coefficients. Furthermore, the model depends on two other forecast parameters: clouds and surface mixing depth. It goes without saying that the model results can be no better than the forecast values used in it.

Thirdly, the model gives acquisition ranges assuming there is a clear line-of-sight to the target. Of course, clouds will present a problem if they are located at or below flight level. Pilots usually know from experience how difficult it is to acquire a target in such a situation. Efforts to use probability of cloud-free-line-of-sight (CFLOS) estimates have not been too successful.

Fourthly, only some of the sensor and target features have been accounted for. Factors such as target contrast edge length and sensor scan line resolution can have important bearing on lock-on-range. Target features such as orientation and number of contrast edges, and shadows can also be important.

Finally, the calculations are concerned only with the hardware and environment, completely ignoring human factors. In reality, the pilot is in the loop using the TV sensor to detect a target. Many factors are involved in target recognition including target size, orientation, and background clutter. The acquisition range, computed using this publication, represents only that distance at which it is physically possible to first distinguish an object from its background. Therefore, the actual range at which acquisition is achieved is always less than than the true maximum acquisition range. This feature makes verification of the forecasted maximum range nearly impossible. Only cases of underestimating the maximum range can be identified, and even then, the amount of error is not known.

Although the model is limited, this method of estimating maximum acquisition range was determined useful by AWS personnel who supported the PAVE SPIKE visual system during test and evaluation flights of the Low Level Laser Guided Bomb (LLLCB). The RAND WETTA model has also been used to support the TV-Maverick precision guided munitions system during various phases of development and deployment.

For further information on this subject see Cottrell, et al., (1979), Breitling (1982), Duff (1972), or Huschke (1976).

## CHAPTER 2

## INSTRUCTIONS FOR COMPLETING A SAMPLE WORKSHEET

A worksheet (see sample, TV Sensor Target Acquisition Worksheet, on page 2-6) will be used to brief aircrews during mission planning. The instructions for completing this sample worksheet are given below. The sample worksheet has five sections described below in paragraphs A-E. Units may wish to modify this worksheet to meet their special needs.

A. MISSION DATA:
Mission ID: Self-explanatory.
Time on Target (Date/Time): Self-explanatory.
Fit Alt:(Ft AGL). Insert a flight altitude that is representative of the part of
the mission during which the TV sensor will be used.
Target Location: Self-explanatory.
OLatitude: Self-explanatory.
OLongitude: Self-explanatory.
Sun Elevation: (Degrees). Don't calculate this value for Bkn-Ovc cloud cover.
The model always uses a value of 25 degrees for solar elevation angle in this situation. For Clr-Sct
cloud cover, use Appendix A (identical to Appendix E of AWS/TR-79/002 and included in this user's manual
for completeness) to find solar elevation angle for the location and time.
Target Type: Enter descriptions of the target (especially surface color and type) and its
immediate background.
Target Reflectance $(R_t)$ : See Appendix B for all values of $R_t$ .
Background Type: Self-explanatory.
Background Reflectance (R <sub>b</sub> ): Use Appendix B for all values of R <sub>b</sub> for Bkn-Ovc
cloud cover and for Clr-Sct cloud cover with sun elevation above 35°. Use Appendix C for all values of
R <sub>b</sub> in Clr-Sct cloud cover with sun elevation below 35°. For water use Appendix D.
B. SENSOR DATA FOR TV SYSTEM: Identify the type of TV sensor being used.
Threshold Illumination $(I_T)$ : ft-candles. Threshold illumination will range
from 0 to 100. Threshold values required in this section may be classified. These values will probably

be available only from the customer.

Acquisition Threshold Contrast  $(C_{TA})$ : Acquisition threshold contrast will probably have a value near 0.2.

## C. TARGET/BACKGROUND CONTRAST VALUES:

Inherent Contrast  $(C_0)$ : Calculate using the target reflectance  $(R_t)$  and the background reflectance  $(R_b)$ . For example, if  $k_t = .10$  (a truck painted red) and  $R_b = .30$  (concrete), then  $C_0$  is equal to |0.10 - 0.30|/0.30 or 0.67. The second calculation uses the inherent contrast  $(C_0)$  and the acquisition threshold contrast ( $C_{TA}$ ) to find the threshold contrast transmittance (C'). For instance, if  $C_{TA}$  is 0.20 and  $C_0$  is 0.67, then C' is equal to 0.20/0.67 or 0.30.

D. PHYSICAL VARIABLES FOR CONTRAST TRANSMISSION CHARTS: In this section, the user selects. for each of five physical variables, a category which corresponds to the contrast transmission chart headings. There are 360 possible category combinations. Use worksheet entries and the forecast to select the category combination which defines the single chart needed out of the 360 available. Total Target Cloud Cover Category: \_\_\_\_\_ (Clr - Sct, or Bkn - Ovc) Self-explanatory. Background Reflectance Category: percent (0-14, 15-49, or 50-100). Choose a category based on the general scene reflectance and not just on immediate background under the target. See section A of the worksheet and appendices B, C, and D. Solar Elevation Angle Category: degrees (0-10, 11-30, 31-55, or 56-90). For the Bkn-Ovc cloud cover cases, the model has already selected the 11-30 degree category. For Clr-Sct cloud cover, select the category which includes the solar elevation angle from section A of the worksheet. Surface Mixing Depth Category: \_\_\_\_\_ feet (below 50, 1500, 3000, or 6000). Select the nearest value based on the forecast. For example, if the forecast value is 4,000 feet, choose the 3,000 foot category. Surface Visibility Category: \_\_\_\_\_ miles (1, 3, 5, 7, 10, or 15). Choose the surface visibility category based on the forecast visibility for the target area at the mission time. There will be a chart in the Appendix II headed with the five values specified above. To find the correct chart, use Tables 1-4 as follows. First, find the correct table based on the values for cloud and reflectance. All the page numbers for the Bkn-Ovc cloud cases are given in Table 1. Tables 2-4 have the page numbers for the Clr-Sct cases. Table 2 has page numbers for background reflectances of 0-14 %. Tables 3 and 4 have page numbers for background reflectances of 15-49 % and 50-100%, respectively. The correct table for the sample worksheet is Table 3. Once the correct table has been found, locate the row corresponding to the values of solar elevation and surface mixing depth specified on the form. Next, find the column corresponding to the visibility value. Finally, at the intersection of the column and row will be the contrast transmission chart page number in Appendix H. For the sample worksheet the chart page number is II- 185. After locating the chart, find the position on the chart corresponding to the C' and flight altitude values given in sections A and C. From this point, drop vertically down to the X axis and read off the maximum acquisition ground range, which for the sample case is 7,500 feet. In some cases, interpolation between isopleths may be needed. Remember the isopleths of C' are given as tenths. E. ADDITIONAL CALCULATIONS: This section includes calculations that may or may not be needed. If the time over target is within an hour of sunrise/sunset, the absolute amount of visible light illumination becomes important. If the forecasted available lumination (FC) does not exceed the TV sensor threshold illumination  $(I_T)$  then target acquisition is unlikely. The mission planners may want to change the time-over-target or cancel the mission. Furthermore, the maximum acquisition ground range computed in step 1) must be changed to zero. The best procedure is to complete sections A and B first. Then, if the time-over-target is within an hour of sunrise/sunset, go directly to section E. To see if there is

If time on target is within an hour of sumrise/sumset, find Illumination ( $f_c$ ): \_\_\_\_\_\_ft-candles (Appendix E).

enough light, first find the sky illumination (f, which is a function of solar elevation and cloud type/

amount) by using Appendix E.

Availabl	e Lumination (FC):ft-candles, FC - R <sub>max</sub> X f <sub>c</sub> . Too little light if FC <
	go Find the available lumination (FC) by multiplying illumination (f <sub>c</sub> ),
which is about 962 foo	t-candles in the example, by the larger of the target/background reflectances
$(R_{max})$ , 0.3 in the example hold illumination $(I_T)$	mple. If there is enough light, the value of FC will be larger than sensor thres-
Shadows at low su tion range, find the s	on elevation angles may also be a problem. To compute the maximum shadow acquisinadow inherent contrast $(C_0)$ using Appendix F (about 0.61) and recompute the unsmission $(C')$ for the shadow using the same equation ratio described in section $C$
(C' is about 0.33 for	the example). Use the same contrast transmittance chart found previously (section que to find the maximum shadow acquisition ground range winch is about 6,500 rest
Max Shao	low Acquisition Ground Range ft
Finally, the factor for will give the target s	ound in Appendix G (a function of sun elevation) multiplied by the target height shadow length.
G)	. Cloud Cover Clr-Sct then Target Shadow Length = Target Height X (Appendix



TABLE 1. Chart Page Number Locator for all Bkn-Ovc Cases.

			A				Numbe	r
Background	Solar	Surface	(		Visib	ility	,	)
Reflectance	Elevation	Mixing Depth	<u>(1</u>	<u>3</u>	<u>5</u>	7	<u>10</u>	<u>15</u> )
0-14	25	Below 50 1500 3000	2 8 14	ე 9 15	4 10 15	5 11 17	5 12 19	7 13 19
		6000	20	21	22	23	24	25
15-49	25	Below 50 1500 3000 6000	26 32 38 44	27 33 39 45	2 <b>9</b> 34 40 46	20 35 41 47	30 36 42 48	31 37 43 49
50-100	25	Below 50 1500 3000 6000	50 56 62 68	51 57 63 69	52 58 64 70	53 59 65 71	54 60 66 72	55 61 67 73

TABLE 2. Chart Page Number Locator for all Clr-Sct, 0-14 Percent Background Reflectance.

			1	Append	dix H	Page	Numbe	er
Background	Solar	Surface	(		Visil	oility	7	)
Reflectance	<b>Elevation</b>	Mixing Depth	<u>(1</u>	<u>3</u>	<u>5</u>	7	10	<u>15</u> )
0-14	0-10	Below 50 1500 3000 5000	74 80 86 92	75 81 87 93	76 82 83 94	77 83 89 95	78 84 90 96	79 85 91 97
0-14	11-30	Below 50 1500 3000 6000	98 104 110 116	99 105 111 117	1.00 106 112 118	101 107 113 119	102 108 114 120	103 109 115 121
0-14	31-55	Below 50 1500 3000 6000	122 128 134 140	123 129 135 141	124 130 136 142	125 131 137 143	126 132 138 144	127 133 139 145
0-14	56-90	Below 50 1500 3000 6000	146 152 158 164	147 153 159 165	148 154 160 166	149 155 161 167	150 156 162 168	151 157 163 169

TABLE 3. Chart Page Number Locator for all Clr-Sct, 15-49 Percent Background Reflectance.

Background	Solar	Surface	, 1	Appen	dix H			er
Reflectance	<u>Elevation</u>	Mixing Depth	<u>(1</u>	<u>3</u>	5	bilit	1 <u>0</u>	<u>15</u> )
15-49	0-10	Below 50 1500 3000 6000	170 176 182 188	171 177 183 189	172 178 184 190	173 179 185 191	174 180 186 192	175 181 187 193
15-49	11-30	Below 50 1500 3000 6000	194 200 206 212	195 201 207 213	196 202 208 214	197 203 209 215	198 204 210 216	199 205 211 217
15-49	31-55	Below 50 1500 3000 6000	218 224 230 236	219 225 231 237	229 226 232 238	221 227 233 239	222 228 234 240	223 229 235 241
15-49	56-90	Below 50 1500 3000 6000	242 248 254 260	243 249 255 261	244 250 256 262	245 251 257 263	246 252 258 264	247 253 259 265

TABLE 4. Chart Page Number Locator for all Clr-Sct, 50-100 Percent Background Reflectance.

D1	G-1	Comfo as	,	Appen	dix H	Page	Numb	er
Background	Solar	Surface	(	_		bilit		)
Reflectance	Elevation	Mixing Depth	(1	<u>3</u>	<u>5</u>	<u>7</u>	<u>10</u>	<u>15</u> )
50-100	0-10	Below 50 1500 3000 6000	266 272 278 283	267 273 279 285	268 274 280 286	269 275 281 287	270 276 282 288	271 277 283 289
50-100	11-30	Below 50 1500 3000 6000	290 296 302 308	291 297 303 309	292 298 304 310	293 299 305 311	294 300 306 312	295 301 307 313
50-100	31-55	Below 50 1500 3000 6000	314 320 326 332	315 321 327 333	316 322 328 334	317 323 329 335	318 324 330 336	319 325 331 337
50-100	56-90	Below 50 1500 3000 6000	338 344 350 356	339 345 351 357	340 346 352 358	341 347 353 359	342 348 354 360	343 349 355 361

## UNCLASSIFIED SAMPLE

# TV SENSOR TARGET ACQUISITION WORKSHEET (MAY BE CLASSIFIED WHEN FILLED IN WITH ACTUAL VALUES)

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4,000 ft A	.57 degree	(See Appendix B	(See Appendix B,C,D
Time on Target (Date/Time): Jan 1 1984/1700 L Flight Alt: 4,000 ft AG	**Latitude: 30.52 N **Longitude: 86.52 W Sun Elevation: 9.57 degree	0.10	0.30 (See
84/1700 I	86.52 W S		
e): Jan 1 190	*Longitude:	Target Reflectance (R <sub>t</sub> ):	Background Reflectance (R <sub>b</sub> ):
get (Date/Tim	30.52 N	Target Re	Background
Time on Targ	*Latitude:		
N	in AFB	Red Truck	Concrete
XAMPLE-R	Egl		
Mission ID: EXAMPLE-RUN	Target Location: Eglin	Target Type:	Background Type:

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DATA
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<u>~</u>

TV-Maverick

0.20
<u>.</u>
(C <sub>TA</sub>
, Acquisition Threshold Contrast
ft-candles,
80
ä
$(I_T)$
Illumination
Threshold

## C. TARGET/BACKGROUND CONTRAST VALUES

# D. PHYSICAL VARIABLES FOR CONTRAST TRANSMISSION CHARTS

Total Cloud Cover over Target:	Clr-Sct	(Clr - Sct, or Bkn - Ovc)
Background Reflectance Category:	15-49	percent (0-14, 15-49, or 50-100)
Solar Elevation Angle Category:	0 -10	degrees (0-10, 11-30, 31-55, 56-90)
Surface Mixing Depth Category:	3,000	feet (below 50, 1500, 3000, or 6000)
Surface Visibility Category:	7	miles (1, 3, 5, 7, 10, or 15)
Go to corresponding chart in Apper	dix H using f	Go to corresponding chart in Appendix H using flight alt and C' find Max Acquisition Ground Range: 7.500

ft

## E. ADDITIONAL CALCULATIONS

For Shadow calculation replace Co with value in Appendix F, recompute C' and repeat Step D. Max Shadow Acqu.6.R. 6,500 ft  $_{\rm tx}^{\rm X}$  f, Too little light if FC < I  $_{\rm T}^{\rm L}$  Light-Go  $_{\rm c}$  No-go ft-candles (Appendix E) If Total Cloud Cover Clr-Sct then Target Shadow Length = Target Height 10 ft X (Appendix G) 5.7 = 57.ft. 962 If time on target within 60 minutes of sunrise/sunset find Illumination  $(\mathbf{f_c})\colon$  \_ ft-candles, FC = R289 Available Lumination (FC):

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THE STAND STATES DEVELOR STANDS DESCRIPTION

## Appendix A

## COMPUTATION OF SOLAR ELEVATION ANGLE



- A-1 <u>Introduction</u>. The following graphical method for computing solar elevation angle (degrees above horizon) is based on Table 169 and equation (1) of Table 170 of List (1966). Calculations consider mean solar time only.
- A-2 Input Data. Data required to compute solar elevation angle (SA) are:

Date (Greenwich Mean Time (GMT))

Time (Greenwich Mean Time (GMT))

Latitude ( $\phi$ )

Longitude

- A-3 Procedure (use worksheet in paragraph A-5).
- a. Enter Figure A-1 with date to find solar declination ( $\delta$ ). Follow date down graph to curve. From intersection with curve, follow graph to left to solar declination. Record solar declination on worksheet.
  - b. Enter Figure A-2 with the time and longitude to find local hour angle (A).
- (1) Enter Figure A-2a with the GMT time and follow to right to curve. This intersection relates GMT time to the Greenwich hour angle (read values at upper edge of figure). From intersection with curve, follow graph down to lower graph edge.
- (2) Using the Greenwich hour angle and the longitude, enter Figure A-2h to find local hour angle (A). Follow the Greenwich hour angle down the graph to the curve representing the longitude. From the intersection with the curve, move left along the graph until the local hour angle is determined. Record local hour angle on worksheet.
- c. Enter Figure A-3 with solar declination, local hour angle, and latitude to find solar elevation angle.
- (1) Figure A-3a produces two values. The curve labeled  $\sin \delta$  is used with Figure A-3b while the curve labeled  $\cos \delta$  is used with Figure A-3c. Enter Figure A-3a from the left with solar declination and intersect the curve labeled  $\sin \delta$ . Record value of  $\sin \delta$  (value at top of graph). With the same solar declination, intersect the curve labeled  $\cos \delta$ . Record value of  $\cos \delta$  (value at bottom of graph).
- (2) With the value of sin  $\delta$  from Figure A-3a, enter Figure A-3b and move upward until the appropriate latitude curve is intersected (interpolate linearly if necessary). Record value of sin  $\phi$  sin  $\delta$ .



- (3) With the value of  $\cos \delta$  from Figure A-3a, enter Figure A-3c and move downward until the appropriate latitude curve is intersected (interpolate linearly if necessary). Use the determined value of  $\cos \phi$   $\cos \delta$  and move to the right into Figure A-3d until the local hour angle is intersected. Record value of  $\cos \phi$   $\cos \delta$   $\cos \delta$ .
- (4) Finally, using the value just determined and the result of Figure A-3b ( $\sin \phi \sin \delta$ ), enter Figure A-3c to find solar elevation angle (SA). Record solar elevation angle (SA).
- A-4 Comments. More accurate values of solar elevation angle can be calculated using the Air Almanac with List's Equation (1). The true local hour angle would be calculated in lieu of the mean local hour angle in order to achieve better accuracy. However, for the purpose intended in this text, the described technique is generally adequate. In most daylight cases, the calculation of solar elevation angle to later infer solar illumination is probably unnecessary since adequate illumination will be available for most TV systems. However, near sunrise and sunset, and under extremely heavy cloudiness calculations of solar elevation should be considered.

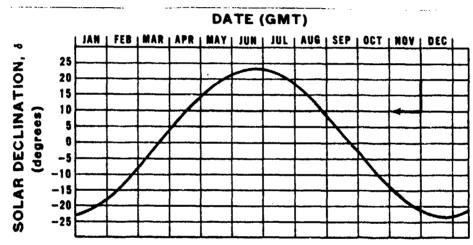


Figure A-1. Solar Declination as a Function of Data (Greenwich Mean Time).

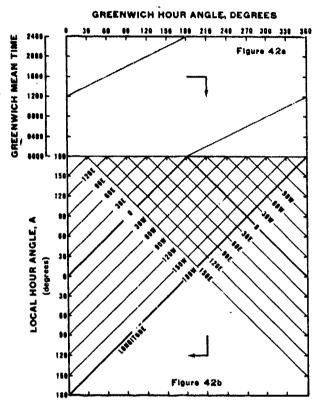
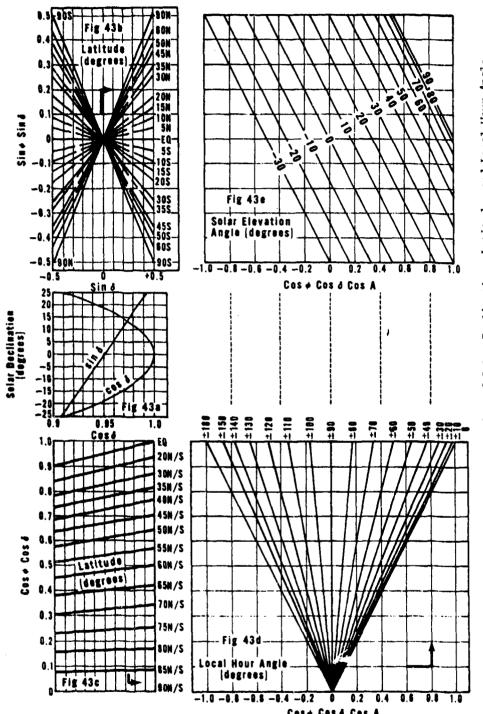


Figure A-2. Local Hour Angle as a Punction of Greenwich Mean Time and Longitude.



Solar Elevation Angle as a Function of Solar Declination, Latitude, and Local Hour Angle. Figure A-5.

Date (GMT)  Time (GMT)  Latitude (φ)  Longitude  PROCEDURE  a. Enter Figure A-1 with GMT date to find solar declination.  Solar declination (δ)
Time (GMT) Latitude (\$\phi\$) Longitude  PROCEDURE  a. Enter Figure A-1 with GMT date to find solar declination. Solar declination (\$\delta\$)(degrees).  b. Enter Figure A-2 with GMT time and longitude to find local hour angle (A). Local hour angle (A)(degrees).  c. Enter Figure A-3 with solar declination (\$\delta\$), local hour angle (A) and latitude (\$\phi\$) to find the solar elevation angle.  (1) From Figure A-3a, sin \$\delta\$ =, and cos \$\delta\$ =  (2) From Figure A-3b, sin \$\delta\$ sin \$\delta\$ =  (3) From Figures A-3c and A-3d, cos \$\phi\$ cos \$\delta\$ c
Latitude (\$\phi\$)  Longitude  PROCEDURE  a. Enter Figure A-1 with GMT date to find solar declination.  Solar declination (\$\delta\)
Longitude  PROCEDURE  a. Enter Figure A-1 with GMT date to find solar declination.  Solar declination (\delta) (degrees).  b. Enter Figure A-2 with GMT time and longitude to find local hour angle (A).  Local hour angle (A) (degrees).  c. Enter Figure A-3 with solar declination (\delta), local hour angle (A) and latitude (\phi) to fixed the solar elevation angle.  (1) From Figure A-3a,  sin \delta =
PROCEDURE  a. Enter Figure A-1 with GMT date to find solar declination.  Solar declination (δ)(degrees).  b. Enter Figure A-2 with GMT time and longitude to find local hour angle (A).  Local hour angle (A)(degrees).  c. Enter Figure A-3 with solar declination (δ), local hour angle (A) and latitude (φ) to fixed the solar elevation angle.  (1) From Figure A-3a,  sin δ =, and cos δ =  (2) From Figure A-3b,  sin φ sin δ =  (3) From Figures A-3c and A-3d,  cos φ cos δ cos A =
<ul> <li>a. Enter Figure A-1 with GMT date to find solar declination.</li></ul>
Solar declination (δ)(degrees).  b. Enter Figure A-2 with GMT time and longitude to find local hour angle (A).  Local hour angle (A)(degrees).  c. Enter Figure A-3 with solar declination (δ), local hour angle (A) and latitude (Φ) to fixed solar elevation angle.  (1) From Figure A-3a,  sin δ =, and cos δ =  (2) From Figure A-3b,  sin φ sin δ =  (3) From Figures A-3c and A-3d,  cos φ cos δ cos A =
<ul> <li>b. Enter Figure A-2 with GMT time and longitude to find local hour angle (A).  Local hour angle (A)(degrees).</li> <li>c. Enter Figure A-3 with solar declination (δ), local hour angle (A) and latitude (φ) to fix solar elevation angle.  (1) From Figure A-3a,  sin δ =, and cos δ =</li> <li>(2) From Figure A-3b,  sin φ sin δ =</li> <li>(3) From Figures A-3c and A-3d,  cos φ cos δ cos A =</li> </ul>
Local hour angle (A)(degrees).  c. Enter Figure A-3 with solar declination (δ), local hour angle (A) and latitude (φ) to fixed solar elevation angle.  (1) From Figure A-3a,  sin δ =, and cos δ =  (2) From Figure A-3b,  sin φ sin δ =  (3) From Figures A-3c and A-3d,  cos φ cos δ cos A =
<ul> <li>c. Enter Figure A-3 with solar declination (δ), local hour angle (A) and latitude (φ) to fissolar elevation angle.</li> <li>(1) From Figure A-3a,</li> <li>sin δ =</li></ul>
solar elevation angle.  (1) From Figure A-3a,  sin δ =
<ul> <li>(1) From Figure A-3a,</li> <li>sin δ =</li></ul>
sin $\delta$ =, and cos $\delta$ = (2) From Figure A-3b, sin $\phi$ sin $\delta$ = (3) From Figures A-3c and A-3d, cos $\phi$ cos $\delta$ cos A =
<ul> <li>(2) From Figure A-3b,</li> <li>sin φ sin δ =</li> <li>(3) From Figures A-3c and A-3d,</li> <li>cos φ cos δ cos A =</li> </ul>
sin $\phi$ sin $\delta$ = (3) From Figures A-3c and A-3d, $\cos \phi \cos \delta \cos A$ =
(3) From Figures A-3c and A-3d, cos φ cos δ cos A =
(3) From Figures A-3c and A-3d, cos φ cos δ cos A =
A-5 Worksheet to Compute Solar Elevation Angle (SA).  INPUT DATA
Date (GMT) 15 Jun 78
Time (GMT) 1000Z
Latitude ( $\phi$ ) 48 <sup>O</sup> N.
Longitude 10°E
PROCEDURE
a. Thter Figure Λ-1 with GMT date to find solar declination.
Solar declination (8) $+23.3$ (degrees).
b. Enter Figure A-2 with GMT time and longitude to find local hour angle $(\Lambda)$ .
Local hour angle (A) 20 (degrees).
c. Enter Figure A-3 with solar declination ( $\delta$ ), local hour angle (A) and latitude ( $\phi$ ) to f
solar elevation angle.
(1) From Figure A-3a,
$\sin \delta = 0.4$ , and $\cos \delta = 0.92$ .
(2) From Figure A-3b,
$\sin \phi \sin \delta = 0.295$
(3) From Figures A-3c and A-3d,
$\cos \phi \cos \delta \cos A = 0.58$
(4) From Figure A-3e, the solar elevation angle (SA) = $61$ (degrees).
REFERENCES:
AWS/TR-79/00., ELECTRO-OPTICAL HANDBOOK, VOL I, WEATHER SUPPORT FOR PRECISION GUIDED MUNITIONS, 1979, APPENDIX E.

INSTITUTION, WASHINGTON, DC. A-5

## Appendix B

## VISIBLE WAVELENGTH REFLECTANCE VALUES - HIGH SUN

(All R, values,  $R_h$  values for Clr-Sct cloud cover with sun elevation above 35 degrees, or all Bkn-Ovc cloud cases)

BARE SOILS	REFLECTANCE
MUD	.05
DRY LOAM	.16
WET LOAM	.09
DARK, DRY DARK, WET	.13 .08
DARK, DRY (PLOWED)	.08
DARK, WET (PLOWED)	.04
LIGHT, DRY	.18
LIGHT, WET	.10
LIGHT, DRY (PLOWED)	.16
LIGHT, WET (PLOWED)	.06
CLAY, DRY	.23 .16
CLAY, WET RED SOIL/EARTH	.12
DIRT ROAD, WET	.25
DIRT ROAD, WET	.18
CLAY ROAD, DRY	.30
CLAY ROAD, WET	.20
SANDY SOIL, DRY	.25
SANDY SOIL, WET SANDY SOIL, DRY (PLOWED)	.18 .20
	.11
SANDY SOIL, WET (PLOWED) SAND (AVERAGE)	.27
SAND, DRY	.40
SAND, WET	.20
DESERT	.30
DESERT SAND	.35
WHITE SAND	.55
BARE, HARD/PREPARED SURFACES	REFLECTANCE
BARE, HARD/PREPARED SURFACES BLACK ASPHALT RUNWAY	REFLECTANCE
	.03
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT	.03 .05 .10
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD	.03 .05 .10
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD	.03 .05 .10 .15
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE	.03 .05 .10 .15 .19
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE	.03 .05 .10 .15
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE	.03 .05 .10 .15 .19 .30
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY	.03 .05 .10 .15 .19 .30 .30
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET	.03 .05 .10 .15 .19 .30 .30
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE .15 .09
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, DORMANT	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE .15 .09 .18
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, GROWING	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE .15 .09 .18 .13
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, GROWING MOWED GRASS, DORMANT	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE .15 .09 .18 .13 .26 .19
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, GROWING	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE .15 .09 .18 .13
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION  VEGETATION  VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, DORMANT MOWED GRASS, GROWING MOWED GRASS, DORMANT DECIDUOUS TREES, GROWING DECIDUOUS TREES, GROWING CONIFEROUS TREES, GROWING	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE  .15 .09 .18 .13 .26 .19 .18
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION  VEGETATION  VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, DORMANT MOWED GRASS, GROWING MOWED GRASS, DORMANT DECIDUOUS TREES, GROWING DECIDUOUS TREES, GROWING CONIFEROUS TREES, GROWING	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE  .15 .09 .18 .13 .26 .19 .18
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION  VEGETATION  VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, GROWING MOWED GRASS, GROWING MOWED GRASS, DORMANT DECIDUOUS TREES, GROWING DECIDUOUS TREES, GROWING CONIFEROUS TREES, DORMANT CONIFEROUS TREES, DORMANT CORN, GREEN	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE  .15 .09 .18 .13 .26 .19 .18 .12 .14
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION  VEGETATION  VEGETATION  VEGETATION  VEGETATION  TALL GRASS, GROWING TALL GRASS, DORMANT MOWED GRASS, DORMANT DECIDUOUS TREES, GROWING DECIDUOUS TREES, GROWING CONIFEROUS TREES, GROWING CONIFEROUS TREES, DORMANT CORN, GREEN RICE	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE  .15 .09 .18 .13 .26 .19 .18 .12 .14 .12
BLACK ASPHALT RUNWAY DARK VOLCANIC ROCK ASPHALT BLACK TOP ROAD WEATHERED ASPHALT ROAD CONCRETE STONE ROCK, DRY ROCK, WET  VEGETATION  VEGETATION  VEGETATION (AVERAGE) GROUND W/LITTLE VEGETATION TALL GRASS, GROWING TALL GRASS, GROWING MOWED GRASS, GROWING MOWED GRASS, DORMANT DECIDUOUS TREES, GROWING DECIDUOUS TREES, GROWING CONIFEROUS TREES, DORMANT CONIFEROUS TREES, DORMANT CORN, GREEN	.03 .05 .10 .15 .19 .30 .35 .20 REFLECTANCE  .15 .09 .18 .13 .26 .19 .18 .12 .14

PAINTED SURFACES	REFLECTANCE
BLACK	.03
OLIVE DRAB (TANK)	.11
DARK GREEN	.08
SEA BLUE	.08
FOREST GREEN	.09
EARTH BROWN	.10
RED	.10
SEA GRAY	.11
SLATE GRAY	.11
OCEAN GRAY	.15
FIELD DRAB	.15
HAZE GRAY	.25
BLUE GRAY	.26
EARTH YELLOW	.43
SKY GRAY	.50
WHITE	.80
ALUMINUM PAINT	.80
TAN PAINTED STEEL	.50
NO PAINT/RUST	.06
	.00
CONSTRUCTION MATERIALS	REFLECTANCE
RED BRICK	.35
··	• • • •
TAR PAPER ROOF	04
TAR PAPER ROOF WEATHERED STEEL	.04
WEATHERED STEEL	.05
WEATHERED STEEL BARE WOOD	.05 .10
WEATHERED STEEL	.05 .10 .12
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS	.05 .10 .12 .13
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP	.05 .10 .12 .13 .14
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD	.05 .10 .12 .13 .14
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS	.05 .10 .12 .13 .14 .20
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM	.05 .10 .12 .13 .14 .20 .50
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL	.05 .10 .12 .13 .14 .20
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM	.05 .10 .12 .13 .14 .20 .50 .85
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM SNOW	.05 .10 .12 .13 .14 .20 .50 .85
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM SNOW FRESH	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM SNOW FRESH DENSE	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75 .65
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD MELTING	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75 .65
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD MELTING	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE .85 .75 .65 .55
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD MELTING	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75 .65 .55
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD MELTING  ICE WHITE GREY	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75 .65 .55 .35
WEATHERED STEEL BARE WOOD OLIVE DRAB CANVAS OLIVE DRAB BURLAP WEATHERED WOOD ASBESTOS SHEETS STAINLESS STEEL ALUMINUM  SNOW FRESH DENSE MOIST OLD MELTING  ICE WHITE	.05 .10 .12 .13 .14 .20 .50 .85 REFLECTANCE  .85 .75 .65 .55



Appendix C
VISIBLE WAVELENGTH REFLECTANCE VALUES - LOW SUN

Visible Wavelength Reflectance Values ( $R_b$ ) (Clr-Sct cloud cover with sun elevation below 35°)

	SUN	ELEVATION	ANGLE	(DEGREES)
SURFACE		<u>10</u>	<u>20</u>	<u>30</u>
Dark Soil, Dry Park Soil, Wet Light Soil, Dry Light Soil, Wet Sandy Soil, Dry Sandy Soil, Wet Vegetation (Average) Tall Grass, Growing		.22 .17 .34 .26 .34 .27 .25	.16 .11 .29 .21 .30 .23 .22	.14 .09 .21 .13 .27 .20 .19

At the time of publication, the change of visible wavelength reflectance with varying sun elevation angle was available for the limited number of surface types listed above. For surfaces not listed here, use  $R_{\rm b}$  values from Appendix B even though sun elevation angle is below 35°.

## Appendix D

## VISIBLE WAVELENGTH REFLECTANCE VALUES - WATER

Visible Wavelength Reflectance Values, for Water (Winds 2-10 mph at 10 meters, for higher winds decrease values slightly)

SUN ELEVATION ANGLE (DEGREES)	CLOUD CLR-SCT	COVER BKN-0VC
5	.26	.14
10	.25	.14
15	.19	.11
20	.13	.09
30	.08	.07
40	.06	.07
50	.05	. 06
60	.04	.06
70	.04	.06

REFERENCES for Appendices B, C, and D:

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ASSESSED MESSESSES

AWS/TR-79/002, ELECTRO-OPTICAL HANDBOOK, VOL I, WEATHER SUPPORT FOR PRECISION GUIDED MUNITIONS, MAY 79, TABLE 8.

SYSTEMS AND APPLIED SCIENCES CORPORATION, INSOLATION MODEL USERS GUIDE (UNDATED), TABLE 2.

TECHNICAL REPORT EL-81-2, THERMAL MODELING OF TERRAIN SURFACE ELEMENTS, MARCH 1981, TABLE B1. (NIGHT VISION AND ELECTRO-OPTICS LABORATORY, FORT BELVOIR, VA).

RADIATION PROCESSES IN THE ATMOSPHERE, WMO-NO. 309, 1972, TABLES 2.1, 2.2, 2.3, 2.10, 2.15, Figures 2.1, 2.2

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Appendix E

SOLAR ILLUMINATION VS. SOLAR ELEVATION AND CLOUD TYPE

	Fog	.002 .006 .006 .007 .19 .57 .15 .3.4 .22.0
	S.	.002 .007 .02 .02 .24 .72 .72 .1.9 .4.3 .8.9 .63.1 .84.0 .16.3 .27.8 .43.9 .63.1 .16.3 .27.8 .43.9 .63.1 .16.3 .27.8 .27
	les)	.003 .008 .03 .03 .03 .25 .25 .20 .4.5 .9.3 .17.0 .29.0 .20.
(BY TYPE)	SC Strong	.003 .009 .03 .03 .09 .23 .23 .5.2 .10.7 .10.7 .10.2 .10.2 .12.8 .15.7 .189 .221 .256 .294 .333 .415 .415
BROKEN-OVERCAST CLOUD (BY TYPE	As mination in	.004 .01 .04 .12 .12 3.3 7.4 15.2 27.9 47.6 75.0 108. 144. 181. 123. 268. 313. 362. 472. 529. 586.
BROKEN-OVE	(Solar Illı	.005 .01 .05 .14 .14 .3.6 .8.1 .16.7 .30.6 .52.2 .62.4 .118 .158 .199 .244 .244 .294 .343 .397 .457 .709
	<b>S</b>	.007 .02 .03 .05 .2 .65 .20 .5.2 .11.7 .24.1 .44.2 .75.4 .119. .171. .228. .287. .287. .287. .287. .287. .287. .287. .287. .288. .287. .288. .287. .288. .287. .288. .28
	పె	.008 .024 .08 .24 .80 .2.4 6.4 14.4 29.6 54.4 92.8 146. 210. 280. 280. 354. 434. 522. 610. 706. 812. 920. 812. 920.
CLEAR TO	TYPE CLD)	.01 .03 .1 .1 .3 .3 .8 .8 .37 .68 .116 .183 .263 .263 .263 .263 .263 .263 .263 .26
SOLAR	(DEGREES)	24 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 -

REFERENCE: AWS/TR-79/002, ELECTRO-OPTICAL HAPDBOOK, VOL I, WEATHER SUPPORT FOR PRECISION GUIDED MUNITIONS, MAY 79, TABLES 6 AND 7.

## Appendix F

## TARGET SHADOW INHERENT CONTRAST

RELATIVELY CLEAR ATMOSPHERE: VISIBILITIES > 6.2 MILES (10 KM)

		GENERA	L BACKGRO	UND
SOLAR		REFLE	CTANCE (R	<b>b</b> )
ELEVATION	.1	<u>.3</u>	<u>. 6</u>	.8
0.0	.55	.54	.52	.51
30°	. 78	.76	.74	. 72
60°	.86	.84	.81	. 79
90°	.88	.85	.81	. 80

RELATIVELY TURBID ATMOSPHERE: VISIBILITIES < 6.2 MILES (10 KM)

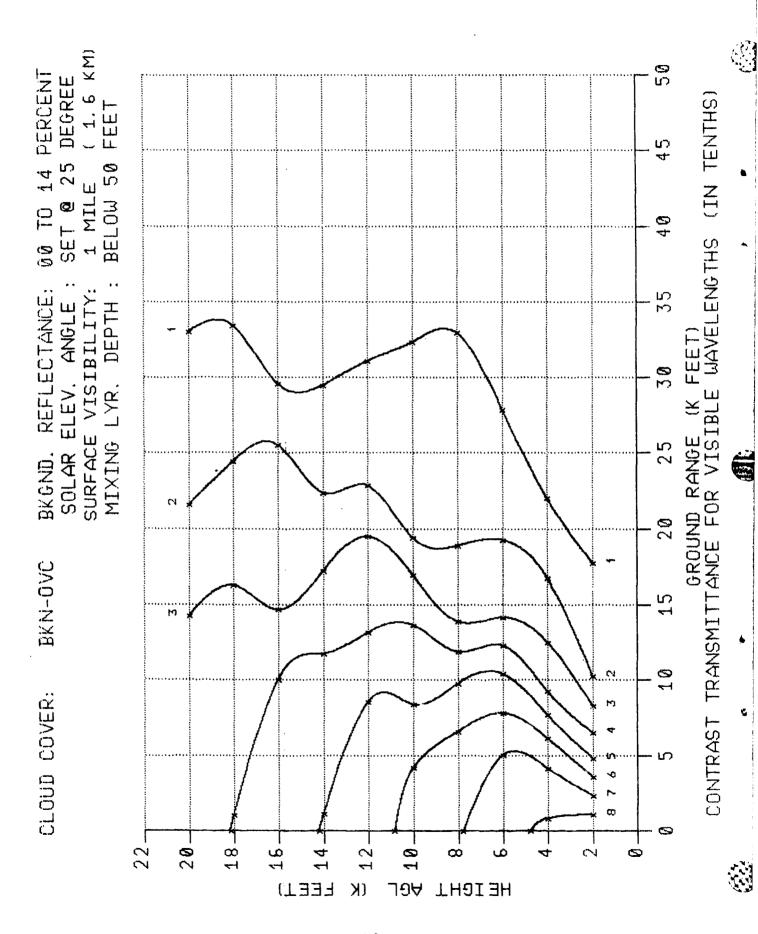
		GENERA	L BACKGRO	מאט
SOLAR		REFLE	CTANCE (R	<sub>b</sub> )
ELEVATION	<u>.1</u>	<u>.3</u>	<u>.6</u>	<u>. 8 .</u>
0°	. 16	. 15	.14	.13
30°	.50	. 47	. 45	.43
60°	. 65	.61	.59	.57
90°	.68	.66	.62	.59

REFERENCE: AFGL/OPI LETTER, AWS/DOOF, INQUIRY ON SHADOWS AS A FUNCTION OF SUNLIGHT, 12 JUNE 1981.

	Append	alx G	
	TARGET SHADOW	LENGTH FACTORS	
	SOLAR ELEVATION ANGLE (SA), DEGREES	SHADOW LENGTH EQUALS TARGET HEIGHT TIMES*	
	1 2 3	28.6	
	4 5 6	11.4	
	8 10 15	7.1 5.7	
	20 25	2.7 2.1	
•	35		
	<b>4</b> 5		
	70	2	
	90		
* FACTOR	= TAN(90-SA)		
* FACTOR	= TAN(90-SA)		
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## Appendix H CHARTS





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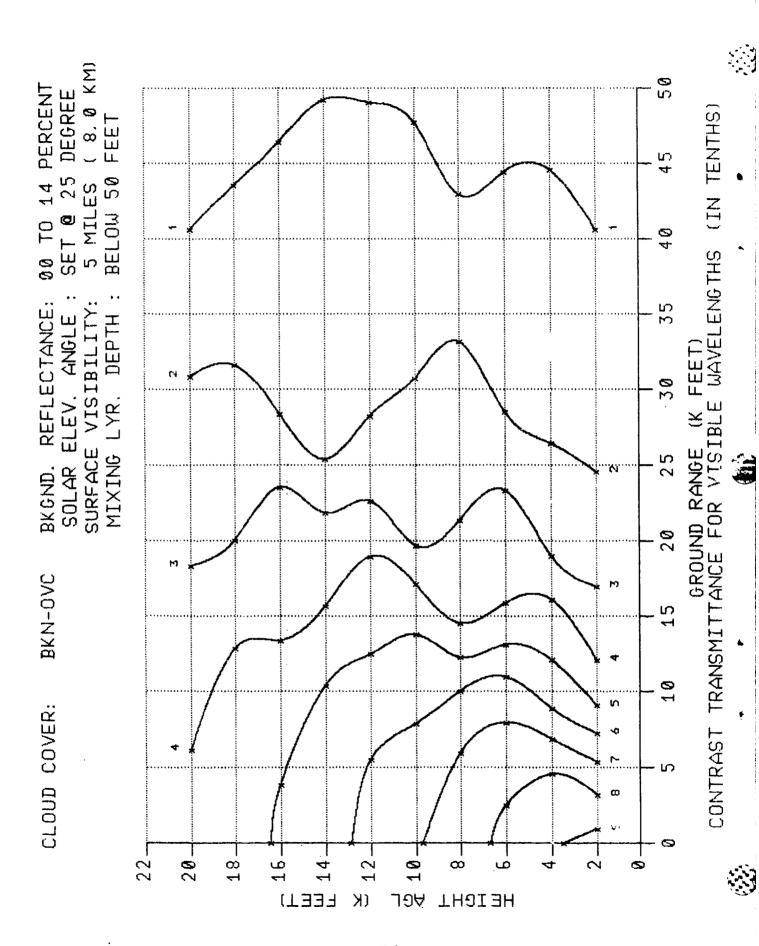
( 4.8 KM) 00 TO 14 PERCENT SET @ 25 DEGREE 3 MILES ( 4.8 KM GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) FEET 44 (J) BELOW 50 40 SOLAR ELEV. ANGLE : MIXING LYR. DEPTH: SURFACE VISIBILITY: 32 REFLECTANCE: 30 25 BKGND. 20 BKN-0VC 1 2 70 CLOUD COVER: ø 22 -18 12-7 20-16-ထ် (S) 14 10 d (T334

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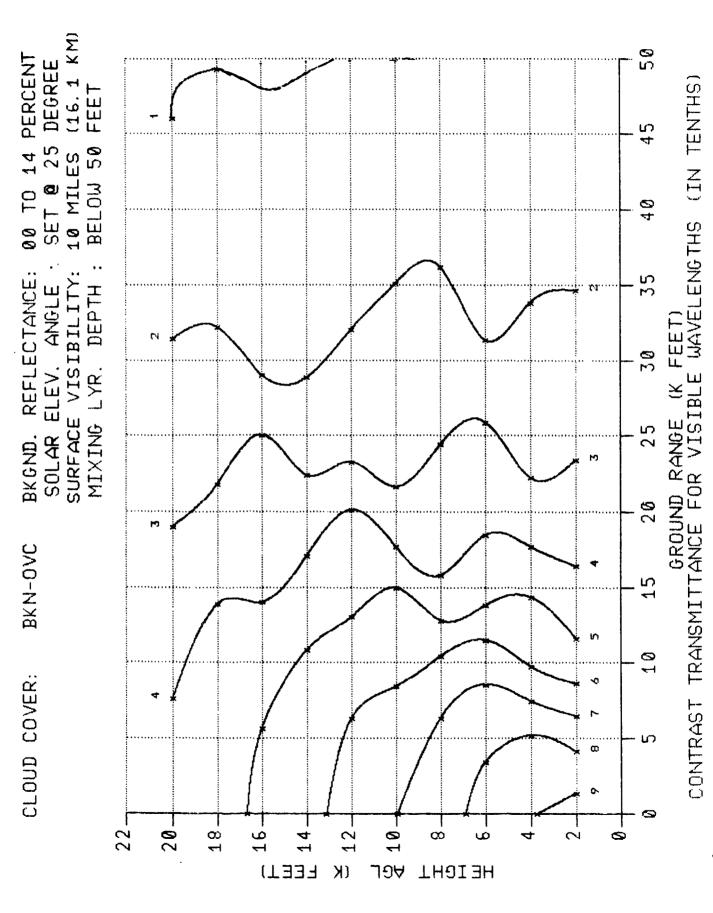
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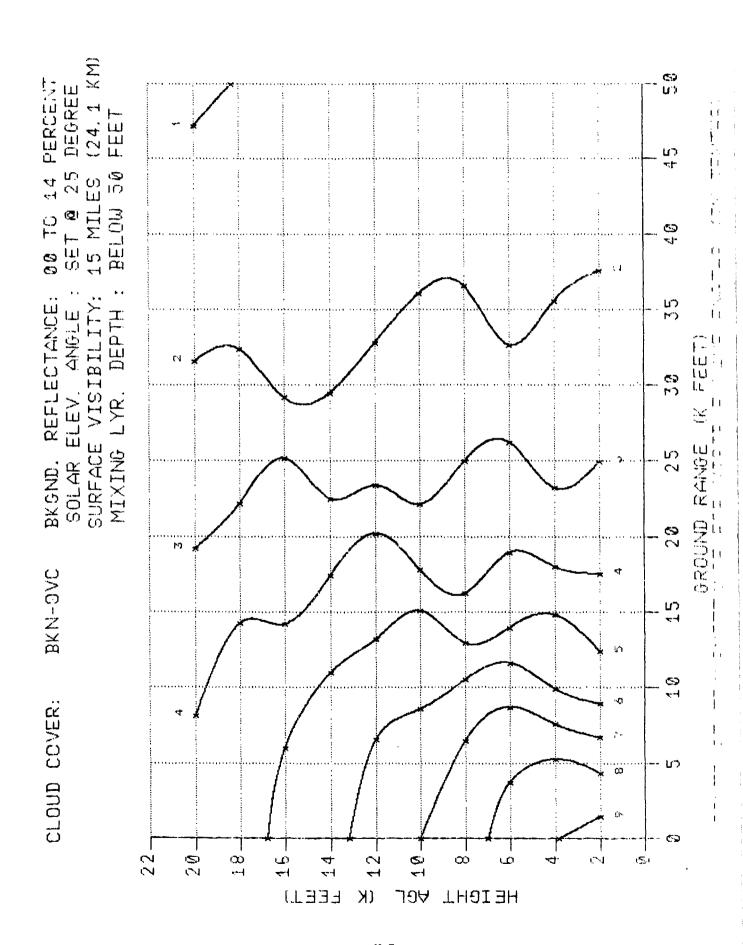
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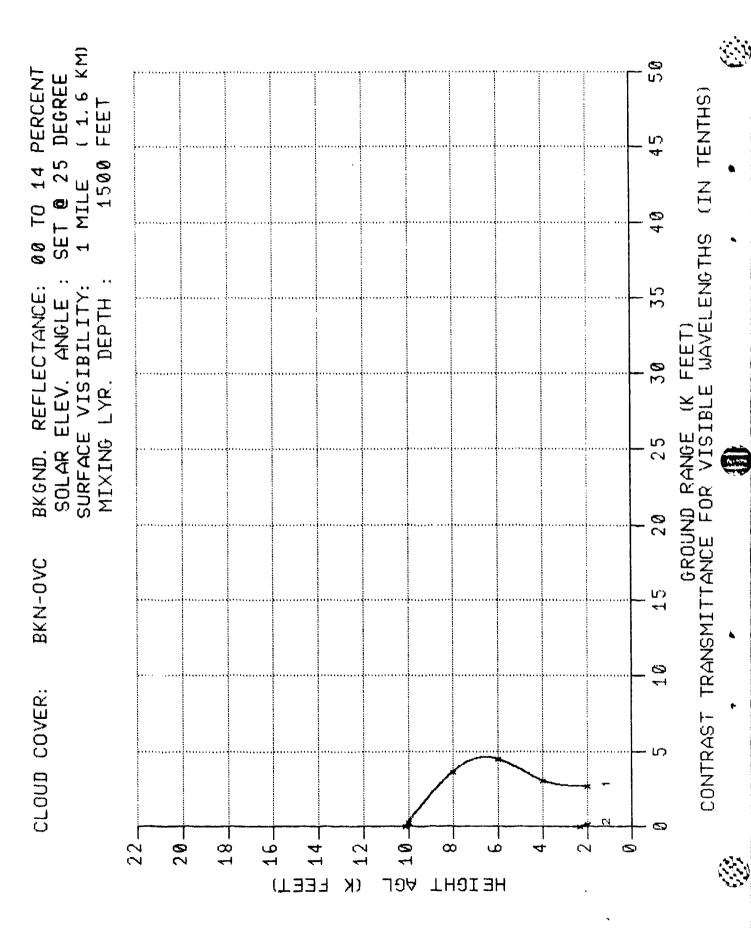
 $\frac{\Sigma}{\Sigma}$ 50 00 TO 14 PERCENT 25 DEGREE (11.3)GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) FEET 4 () BELOW 50 7 MILES SET @ 40 DEPTH: REFLECTANCE: SURFACE VISIBILITY: 3 SOLAR ELEV. ANGLE 30 MIXING LYR. 25 BK GND. 20 BKN-0VC 15 10 CLOUD COVER: 22 -20-18\_ 16-12-٥ **6** 10 ထ် 'n 4 d LEET) ίK ٦٩∀ HE ICHT

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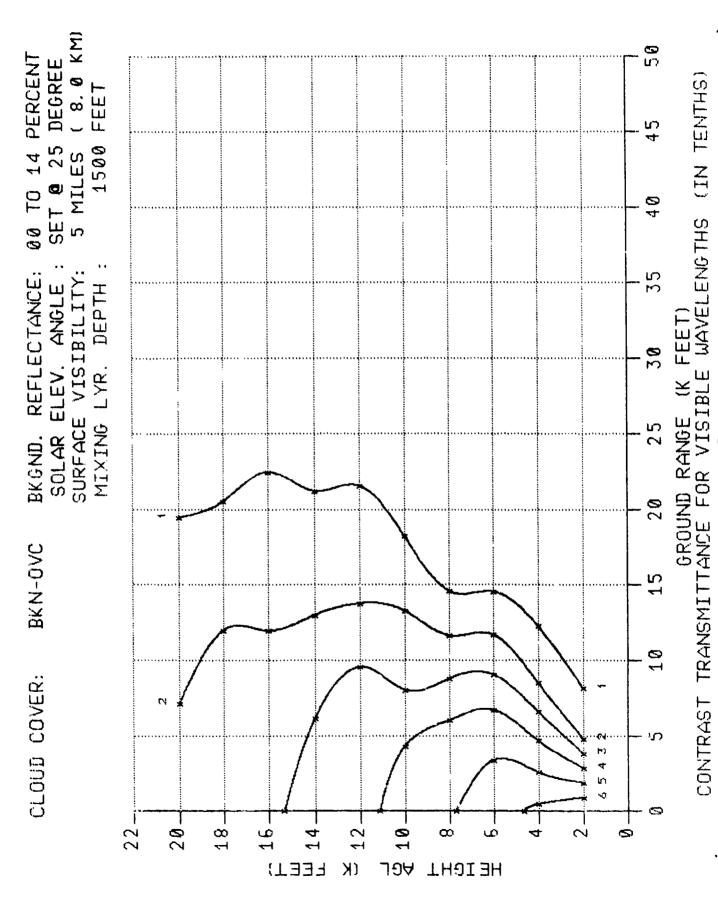


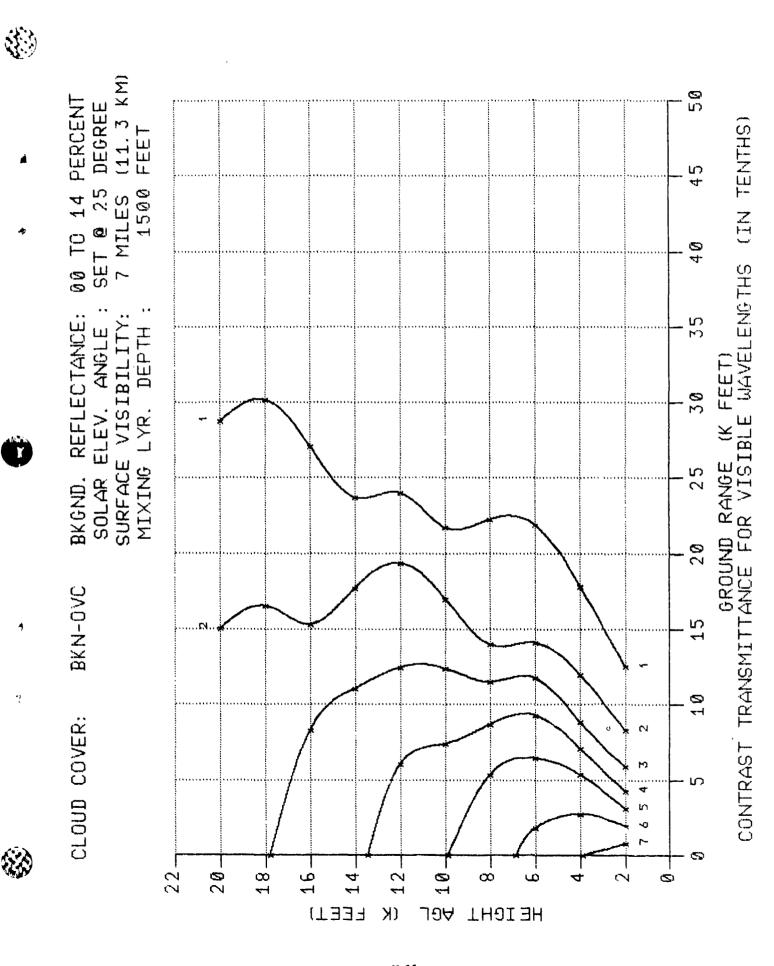


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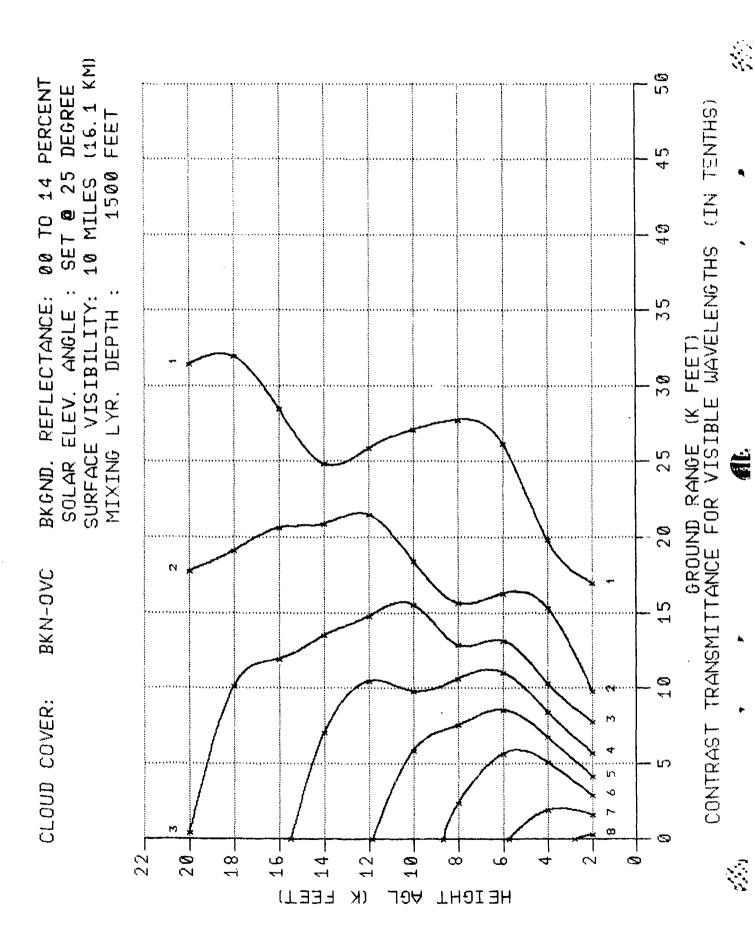
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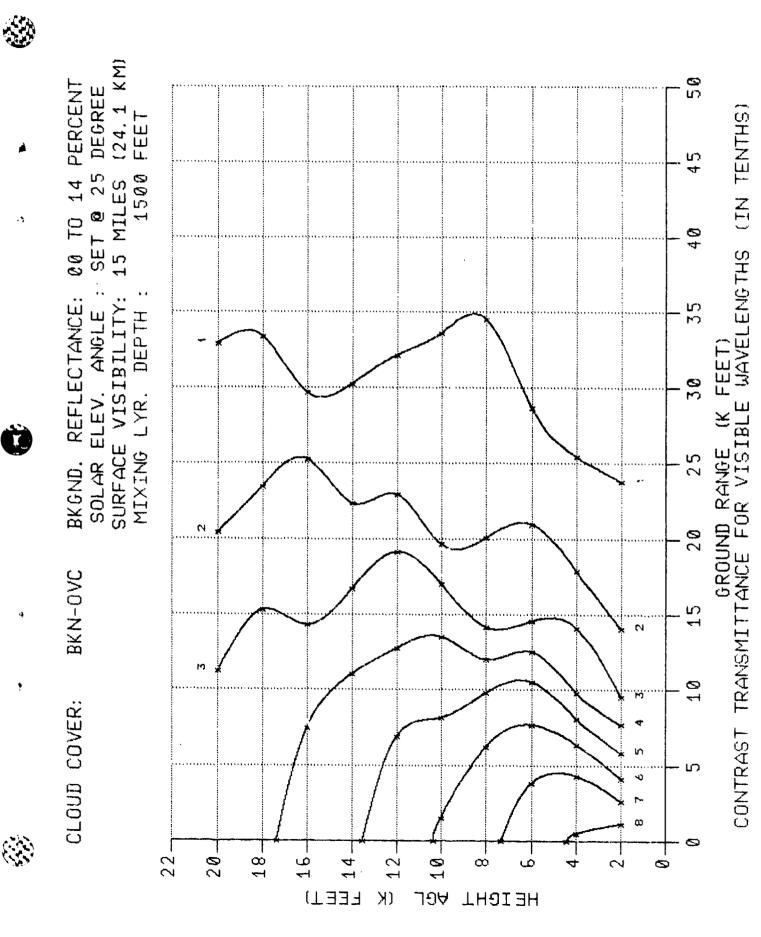


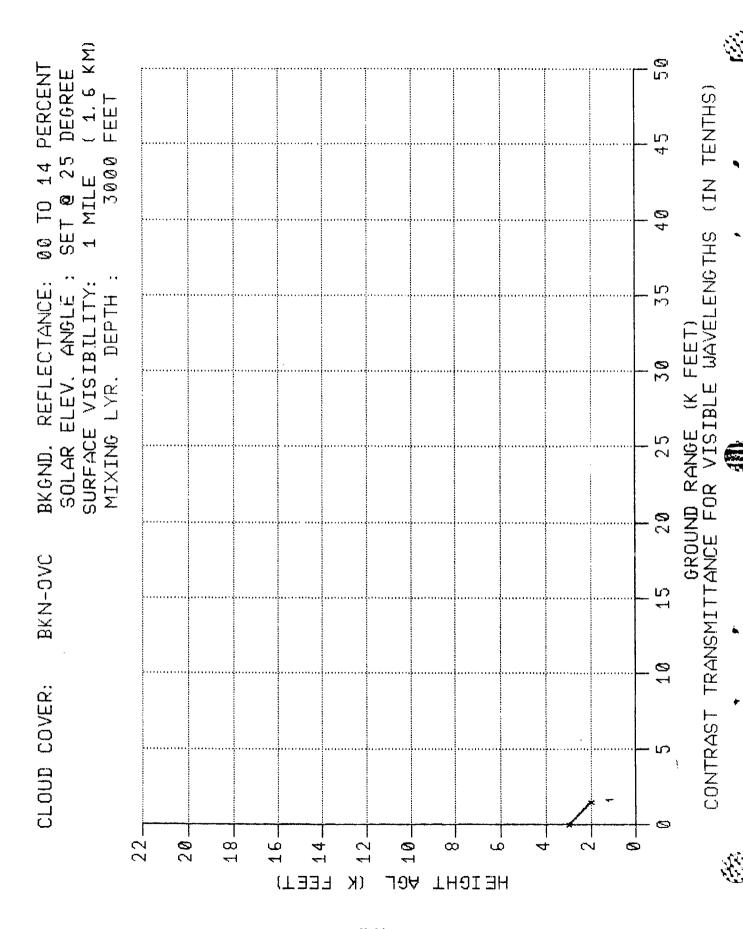


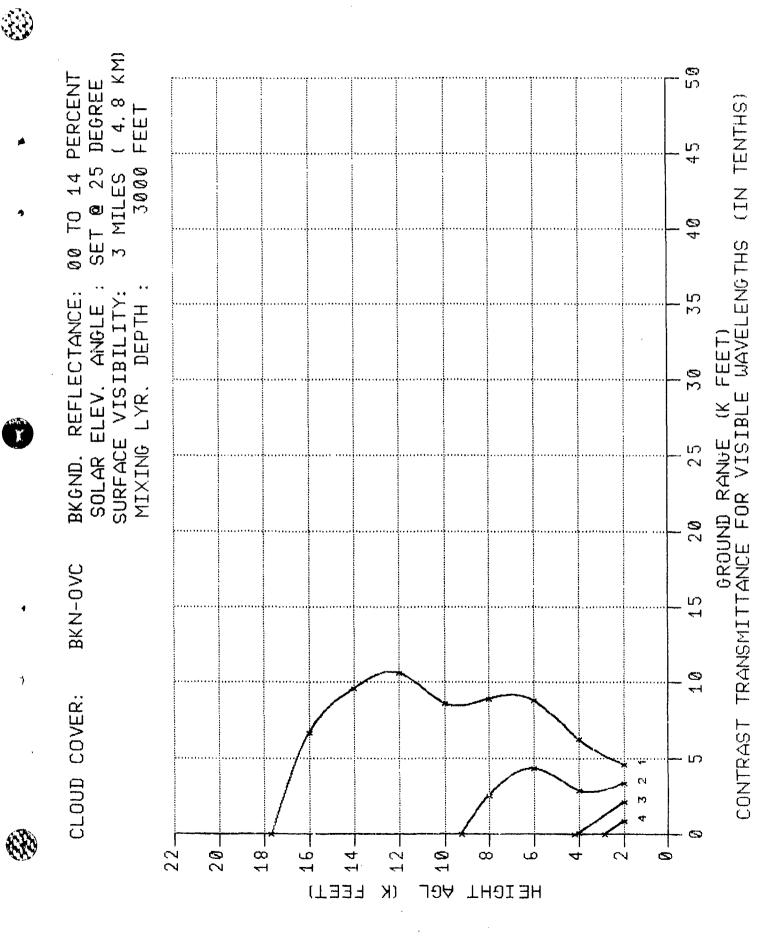
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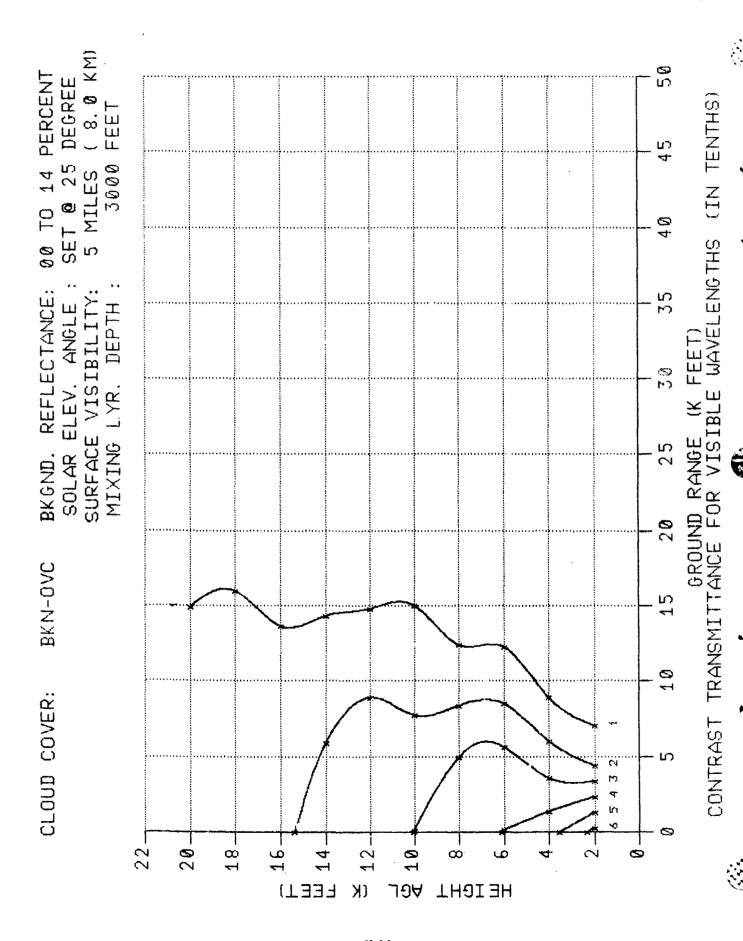
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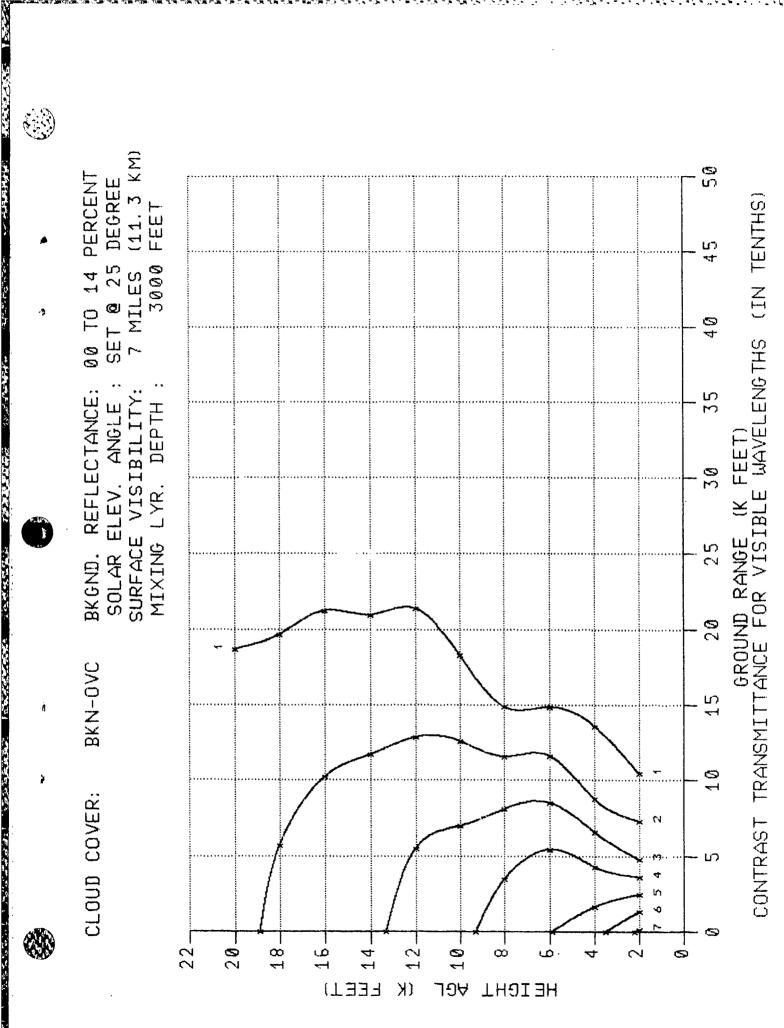


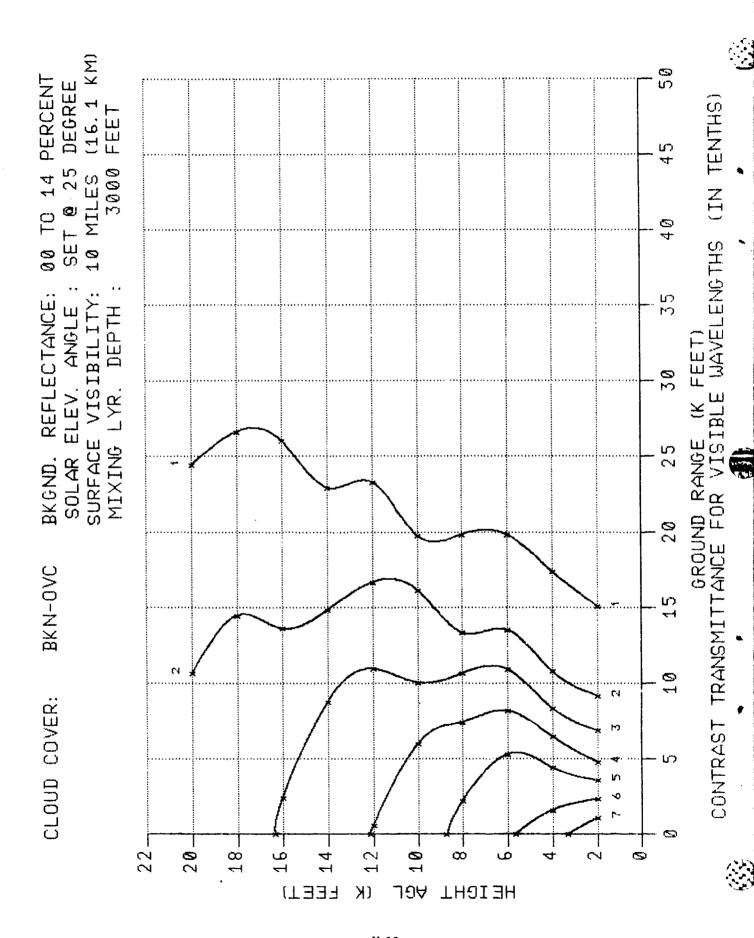


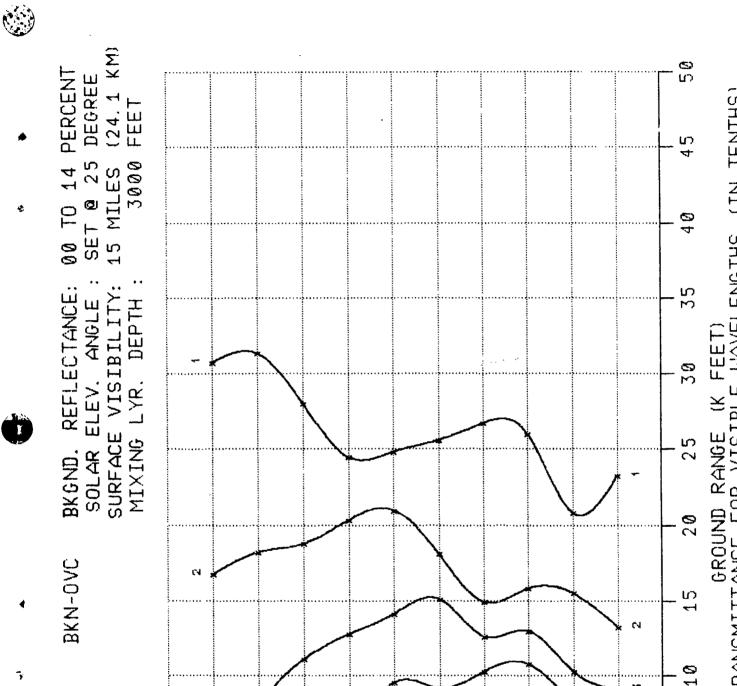












GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

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CLOUD COVER:

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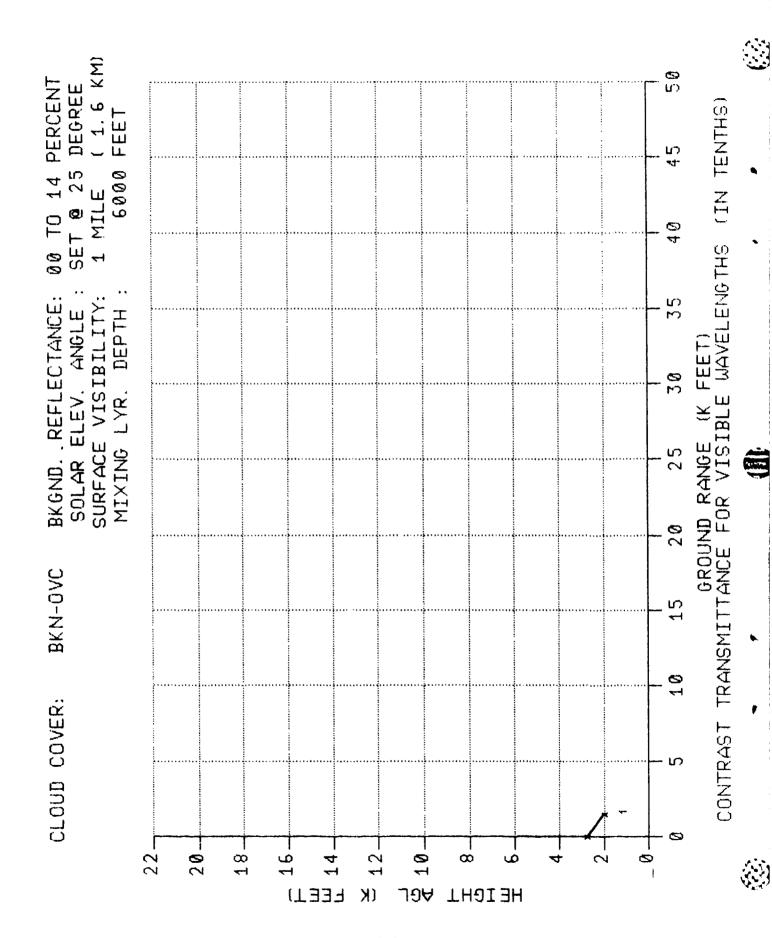
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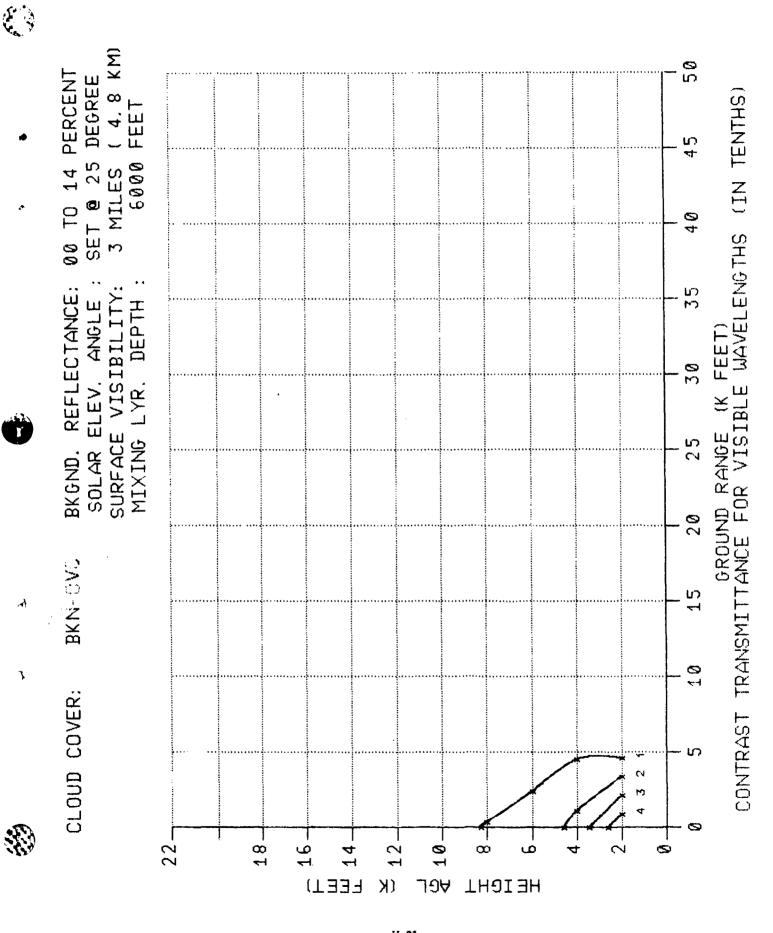
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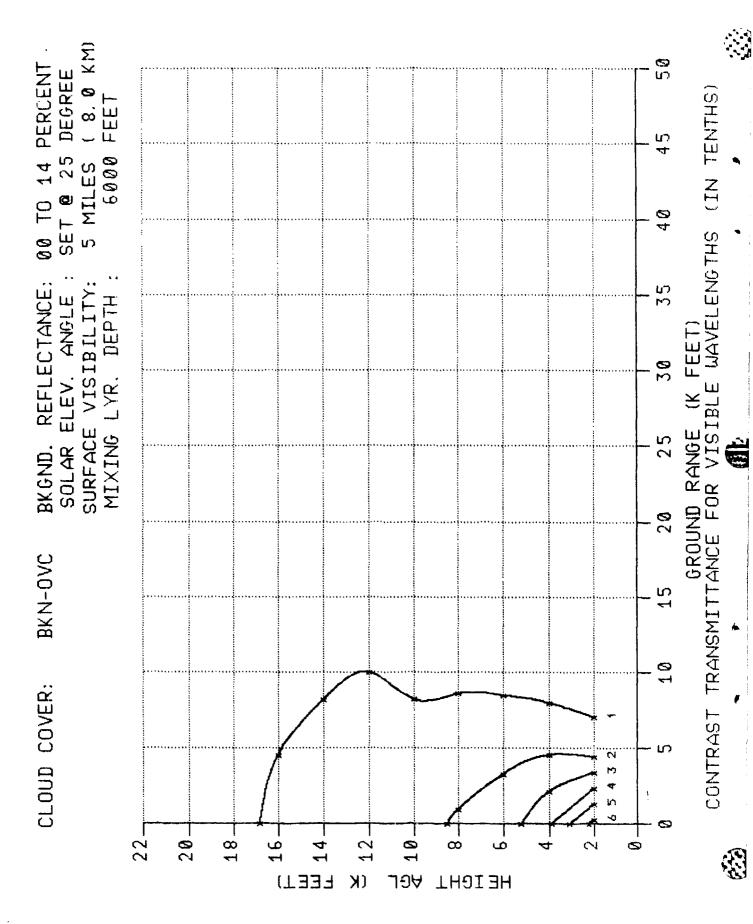
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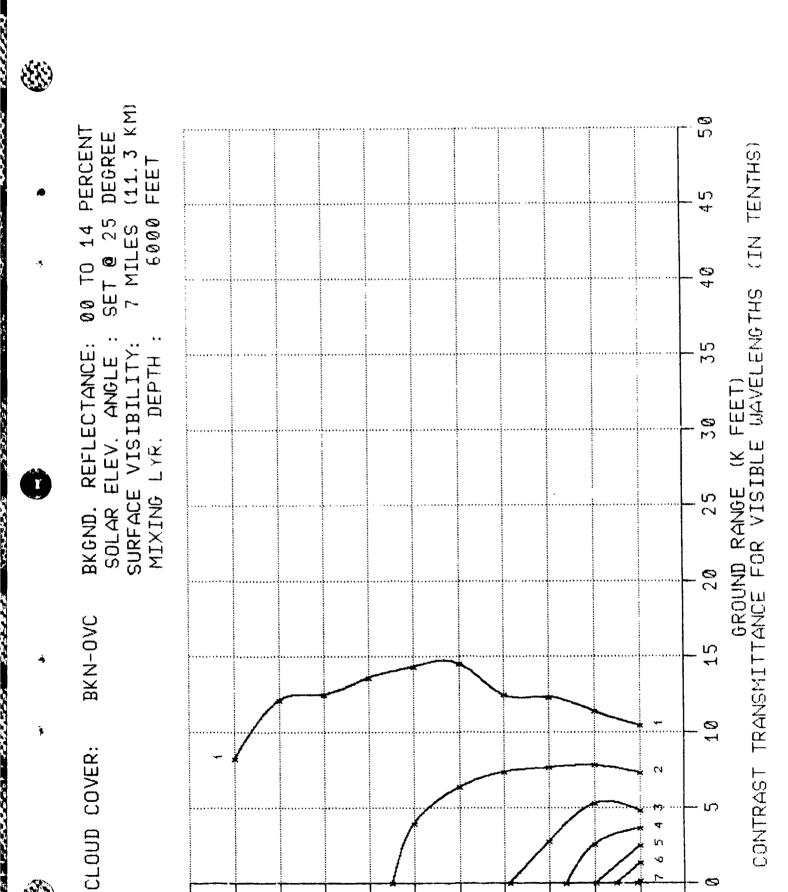
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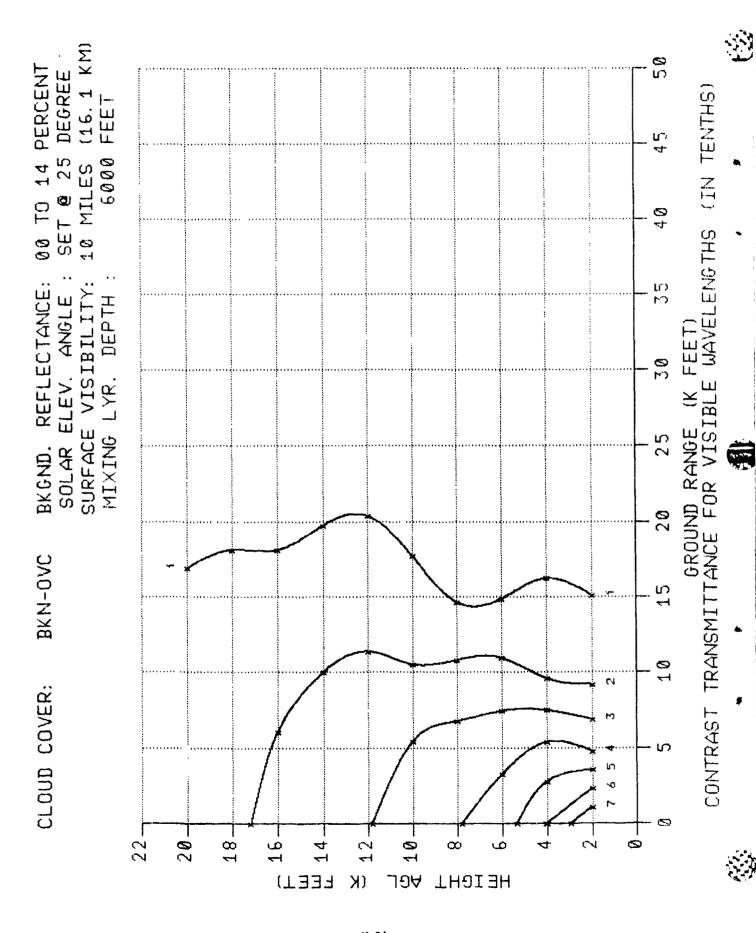
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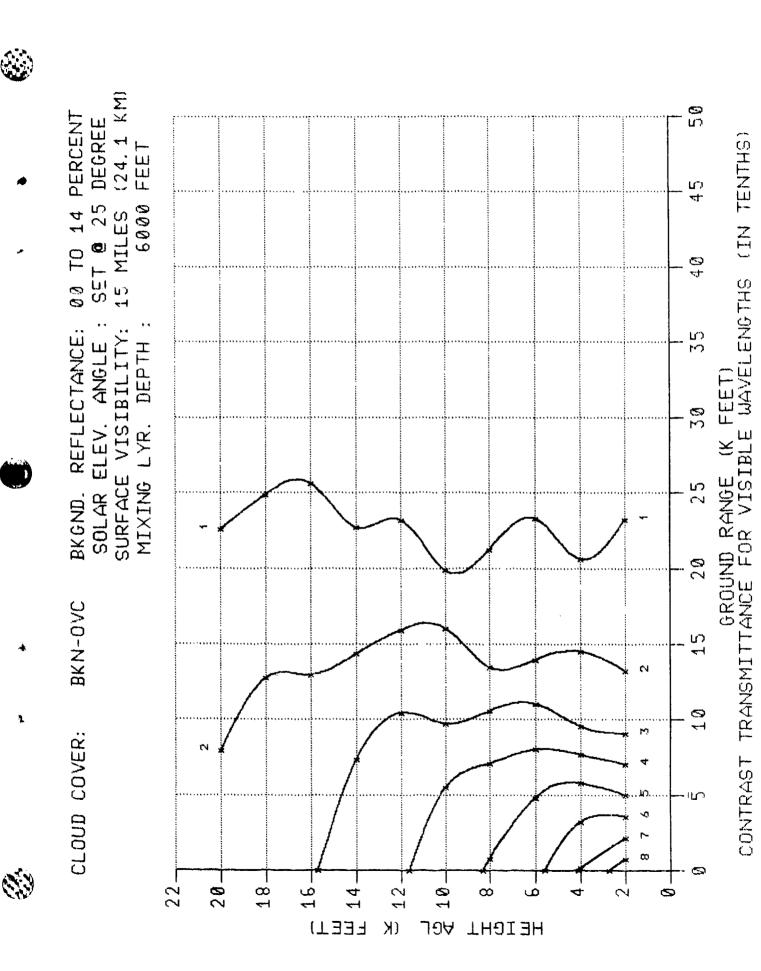
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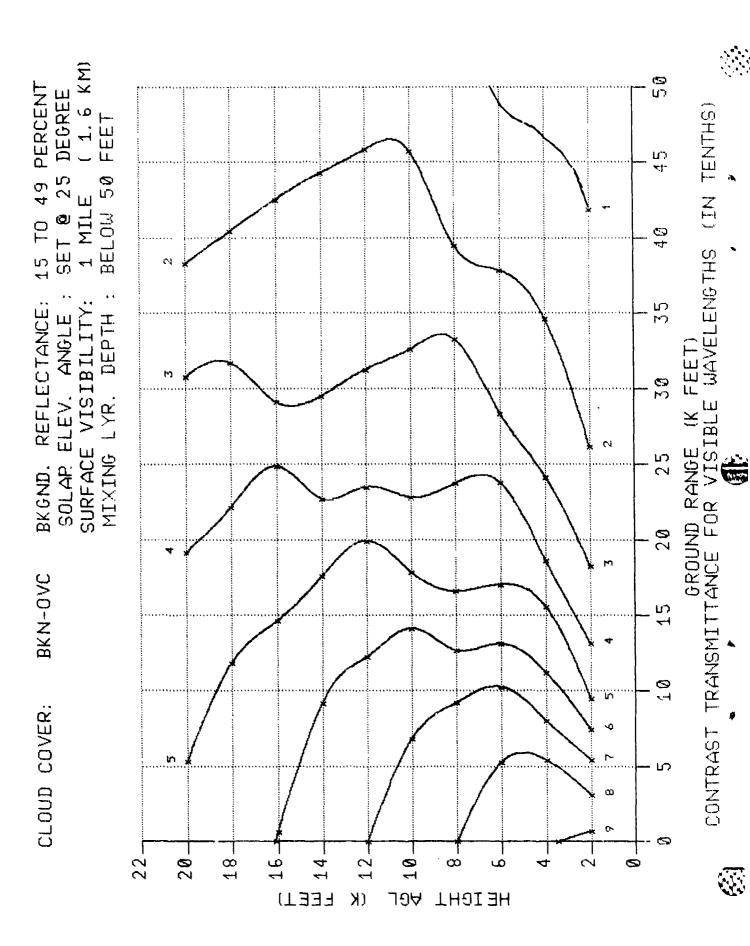
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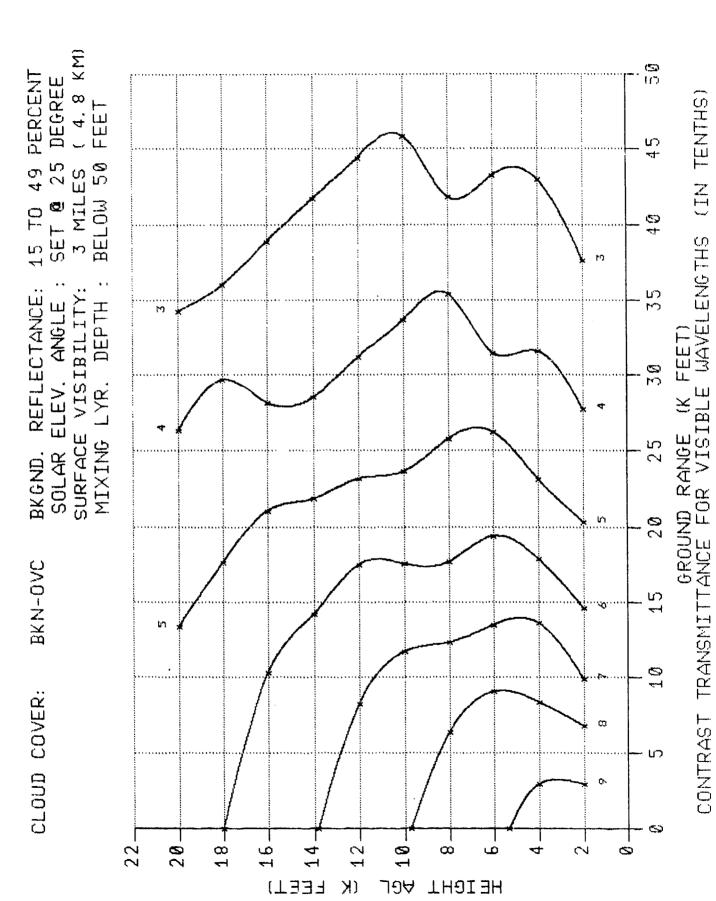


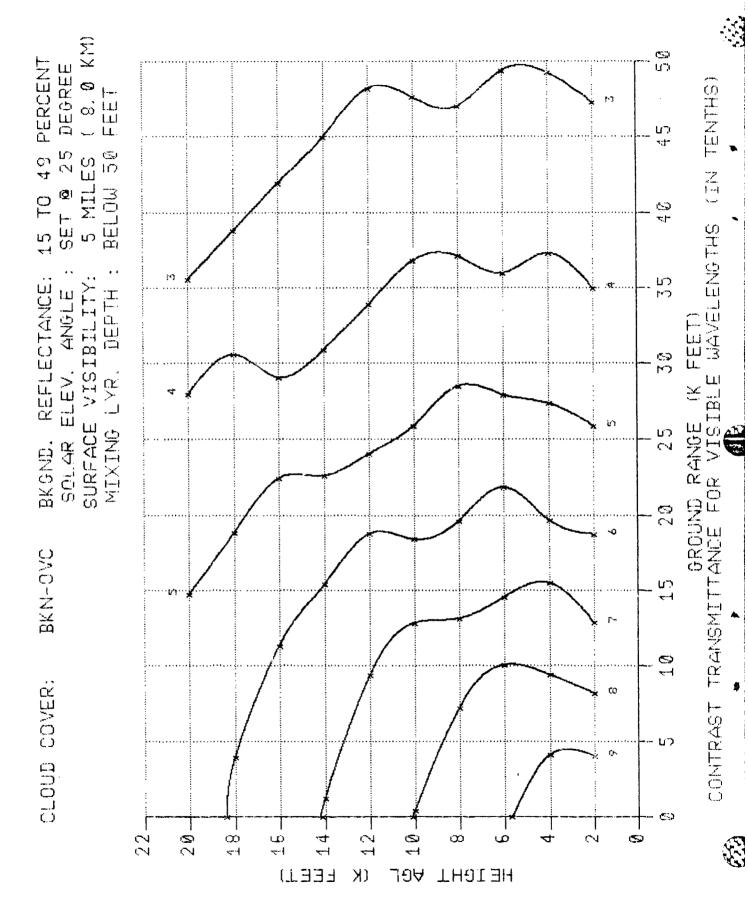


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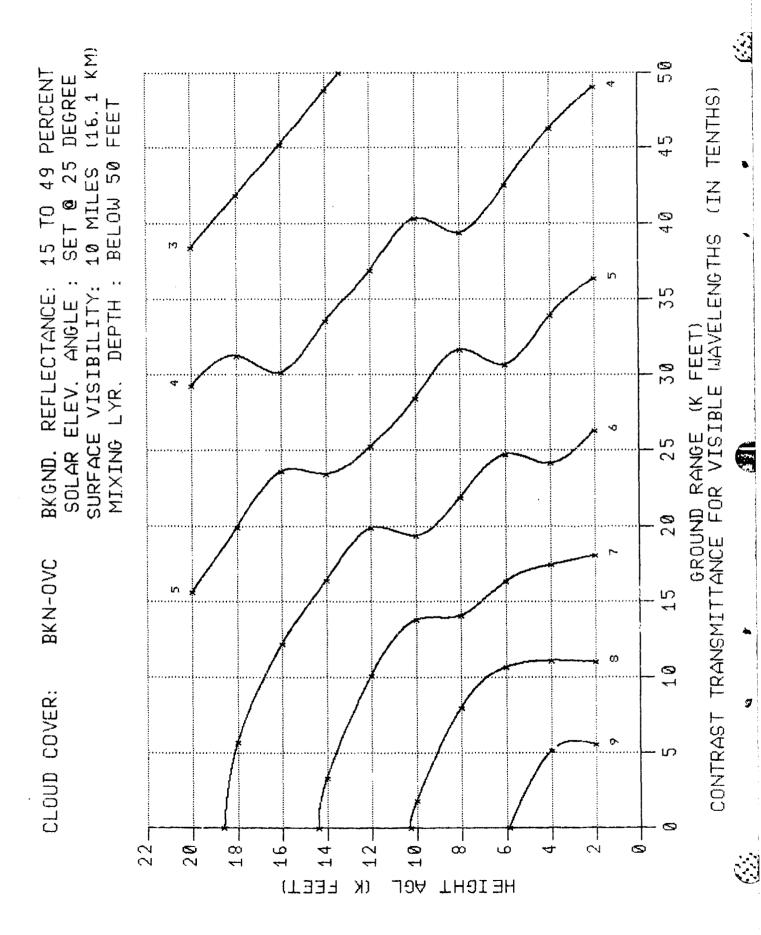


Σ 15 TO 49 PERCENT SET @ 25 DEGREE 7 MILES (11.3 KM ලා ග (11.3 FEET GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) 40 10 BELOW 50 4 3 M SURFACE VISIBILITY: MIXING LYR. DEPTH : SOLAR ELEV. ANGLE : 5 13 13 REFLECTANCE: (S) BKGND. 28 BKN-0VC 15 9 CLOUD COVER: 22 -20-16 9 18-10. 74 <del>,</del> 7 ف Ś တ 4 (LEET) ίK JOA

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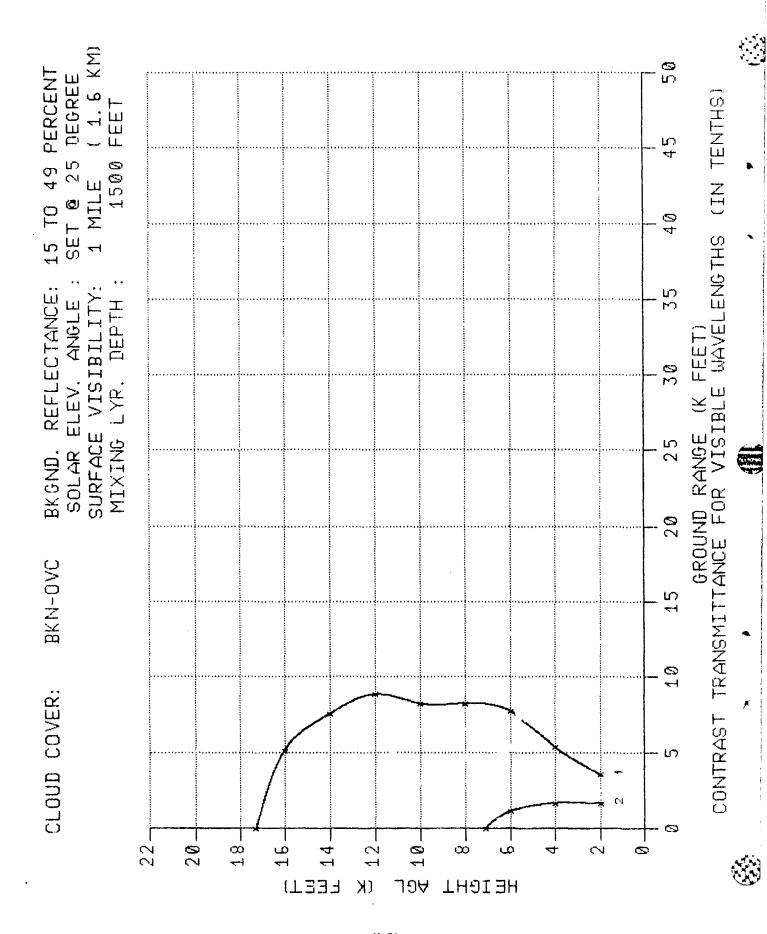
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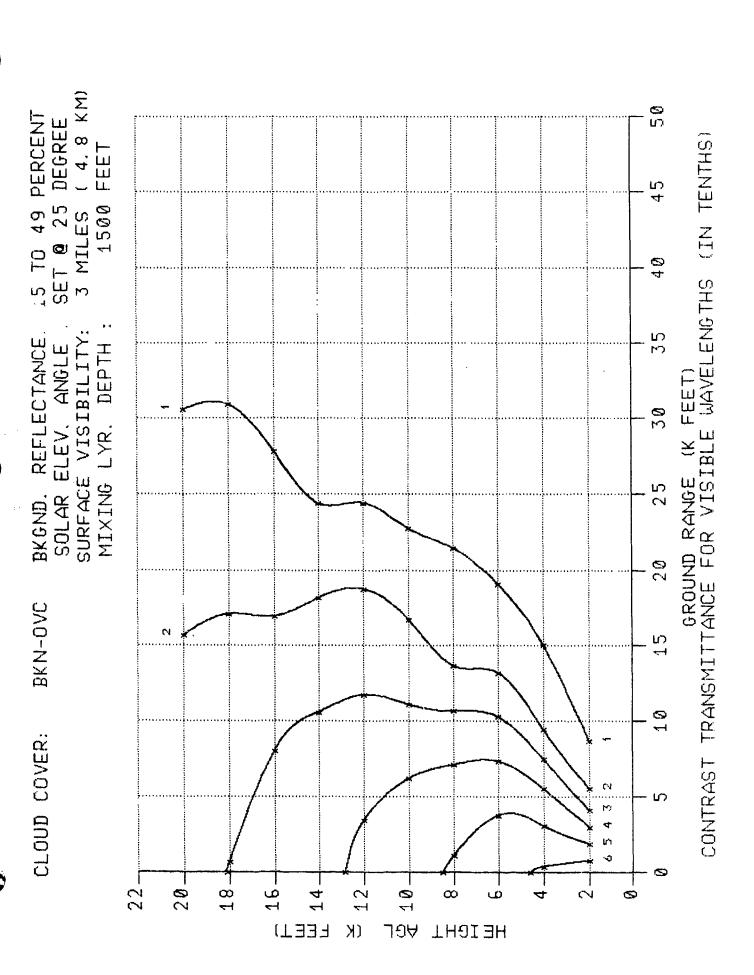
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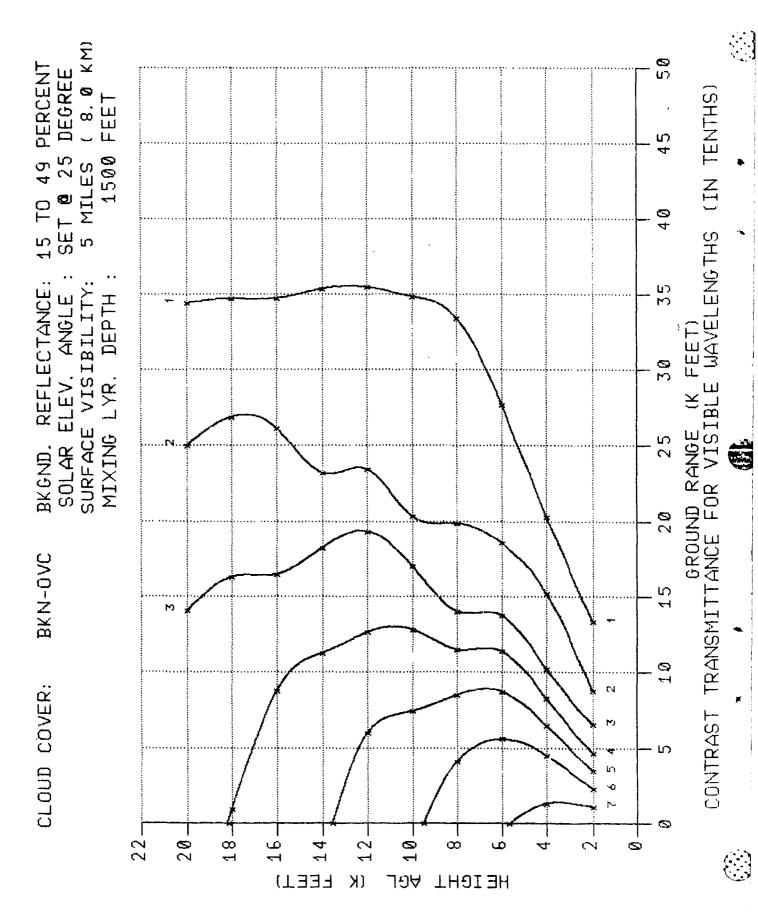
(24.1 KM) ട്ര ഗ 49 PERCENT DEGREE GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) FEET BELOW 50 15 MILES SET @ 40 íń MIXING LYR. DEPTH: SOLAR ELEV. ANGLE : REFLECTANCE: (U) SURFACE VISIBILITY: BKGND. BKN-0VC 15 ₩ 1 CLOUD COVER: 2 (S) 18 10 22-20-ထ ٩ 4 (TEET) 16. 12. ĊĶ 794

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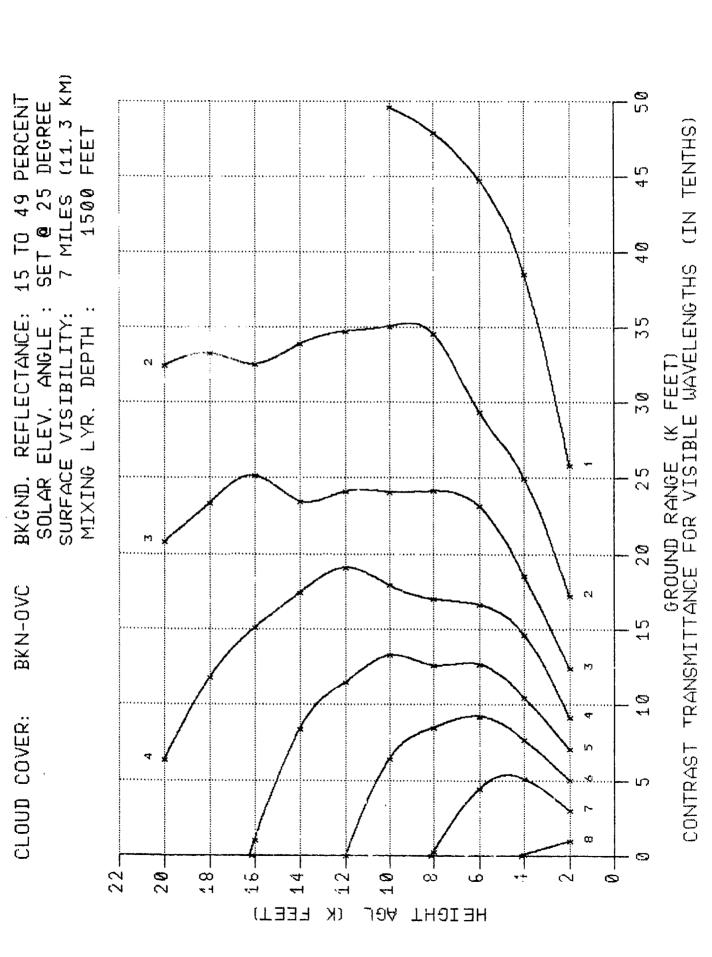


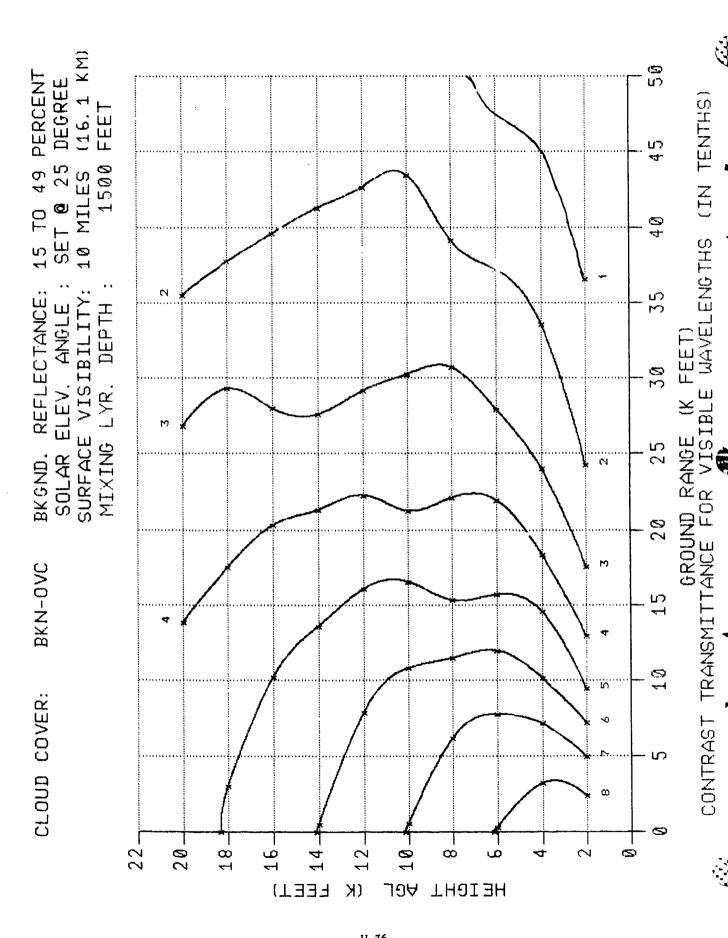


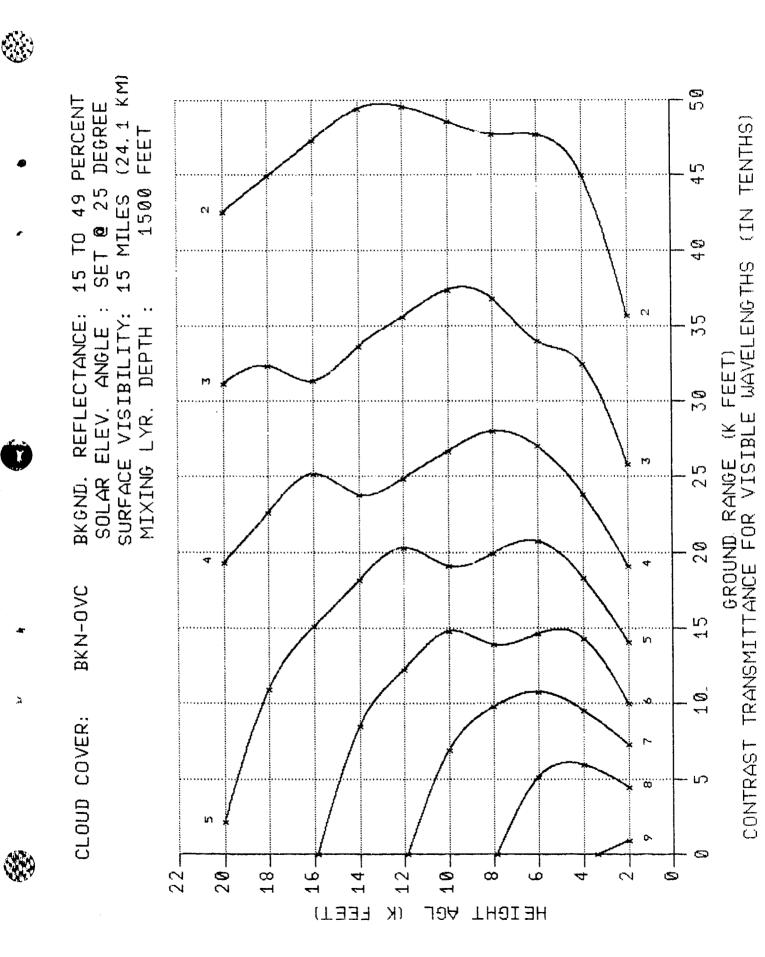
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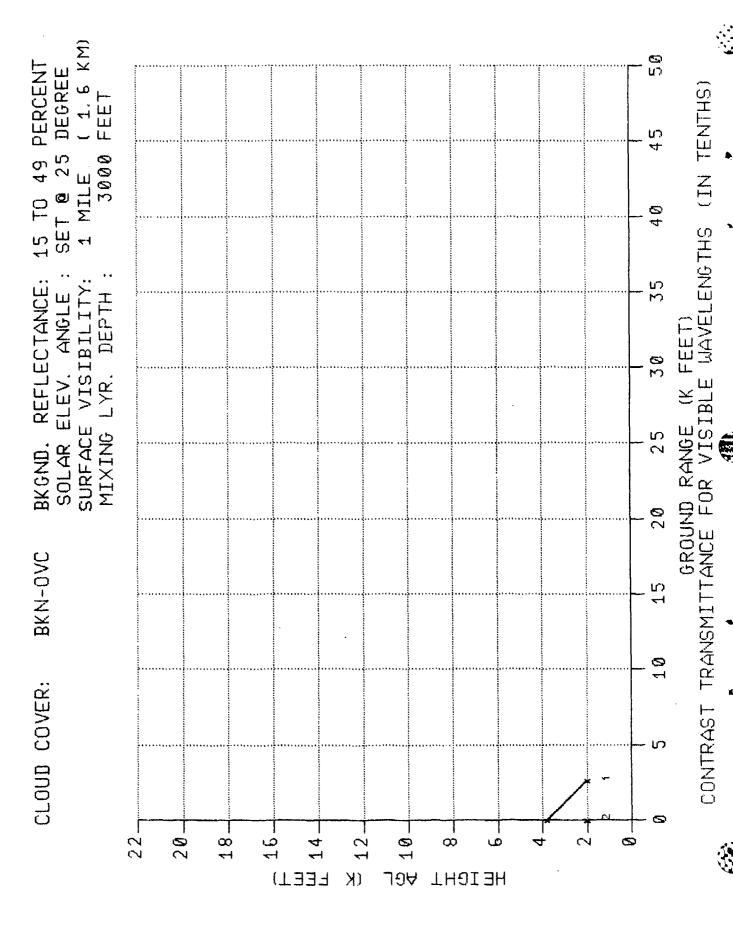


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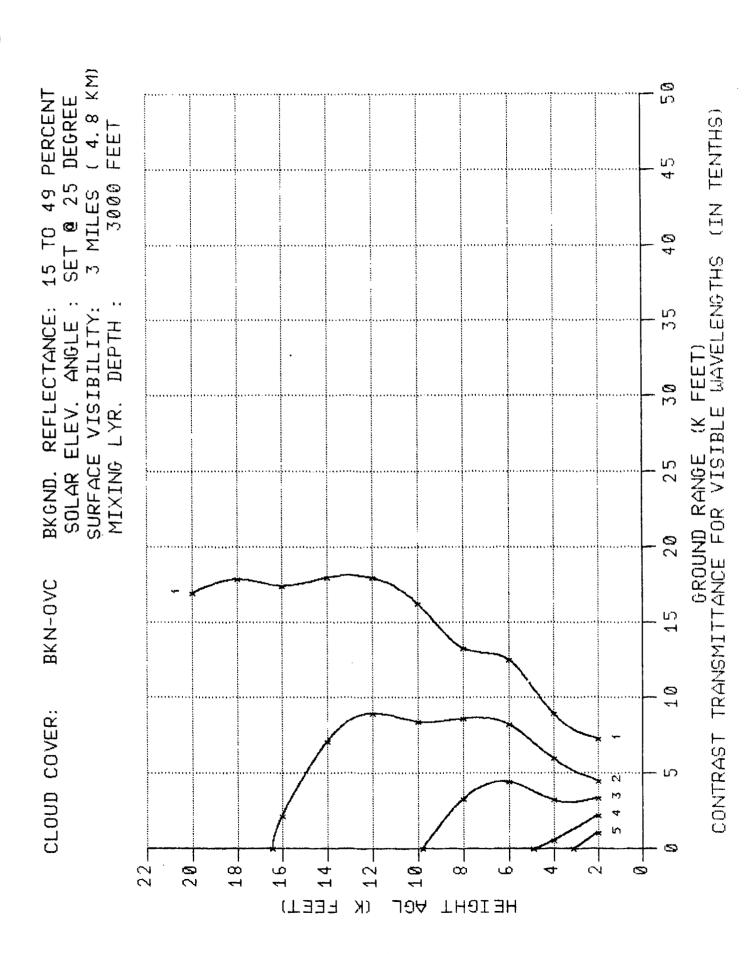


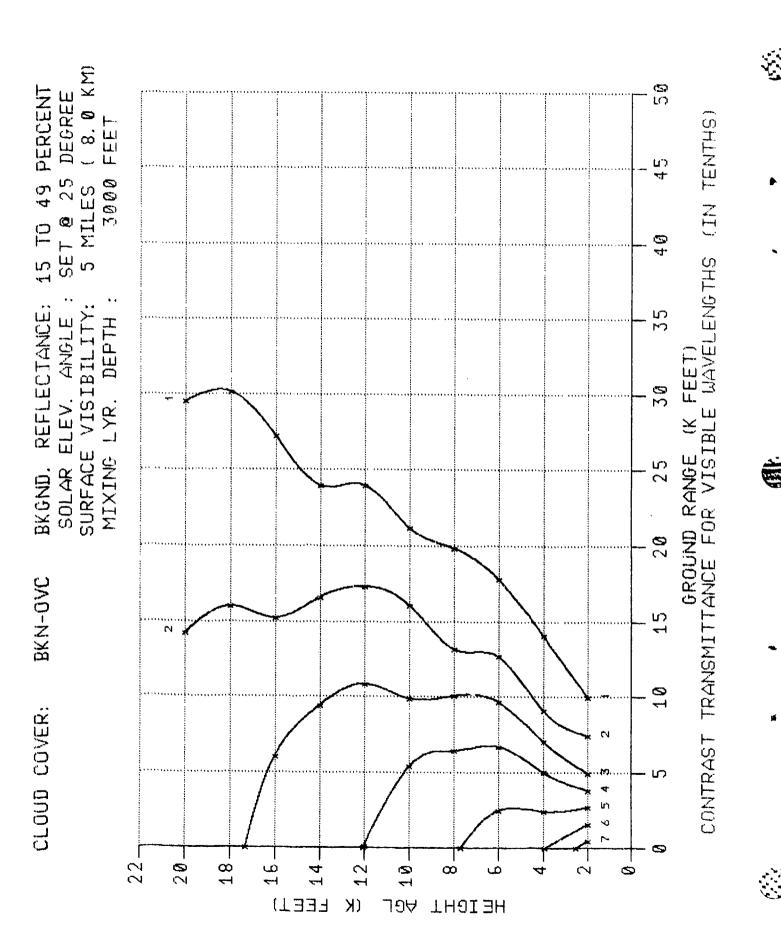




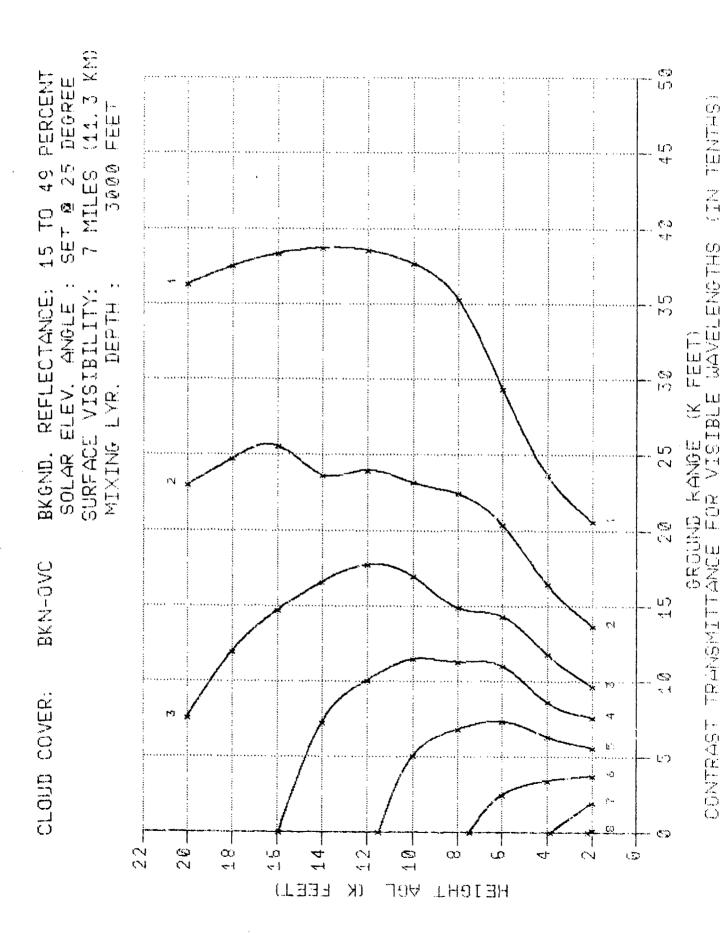


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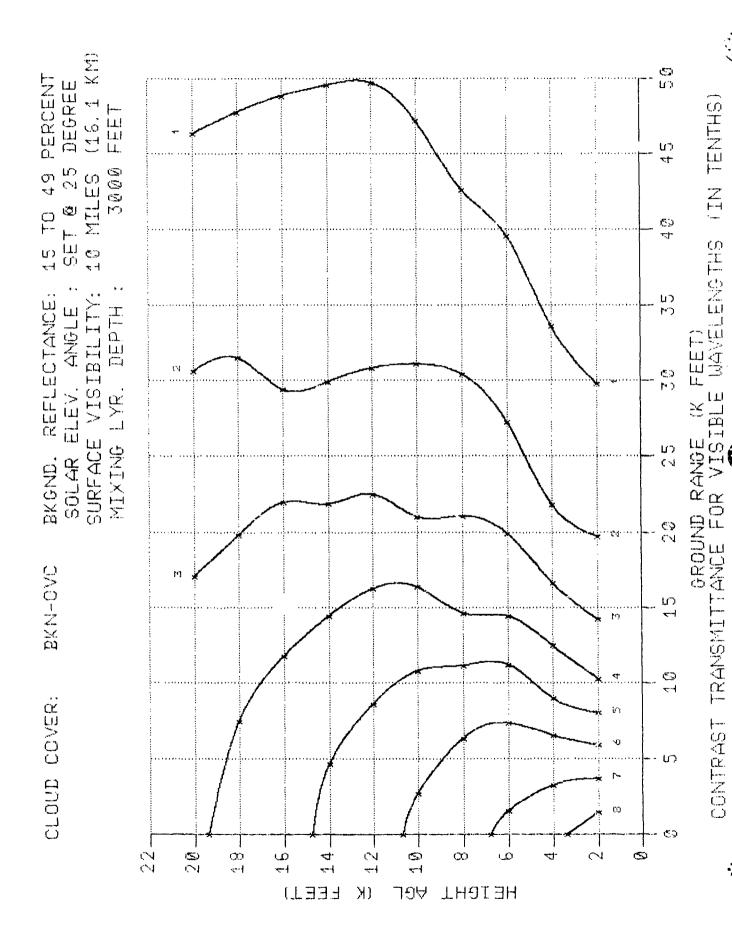


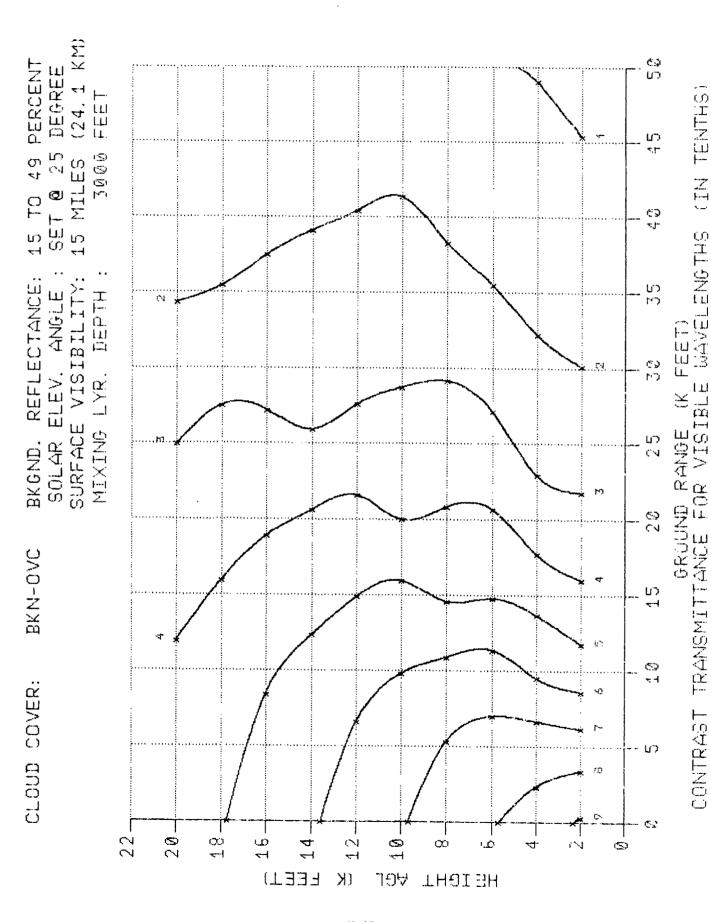
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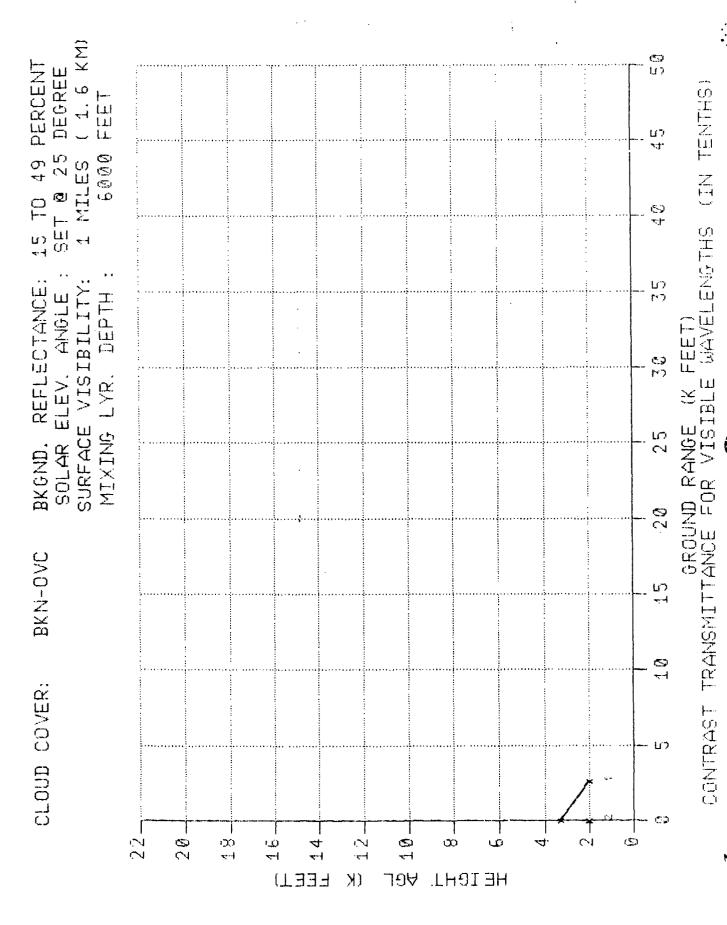


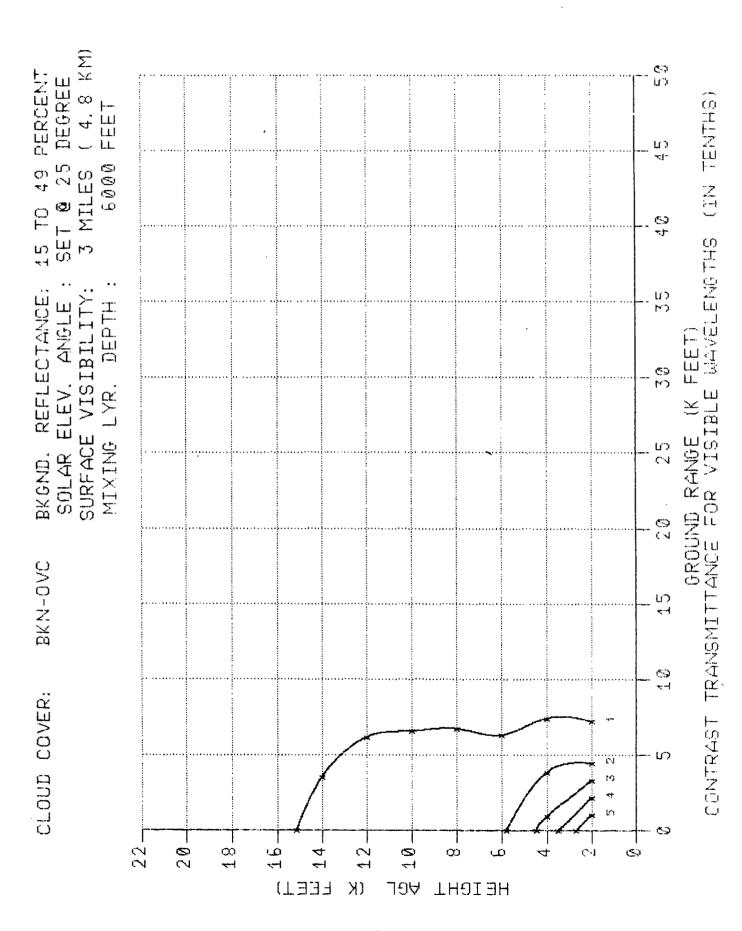


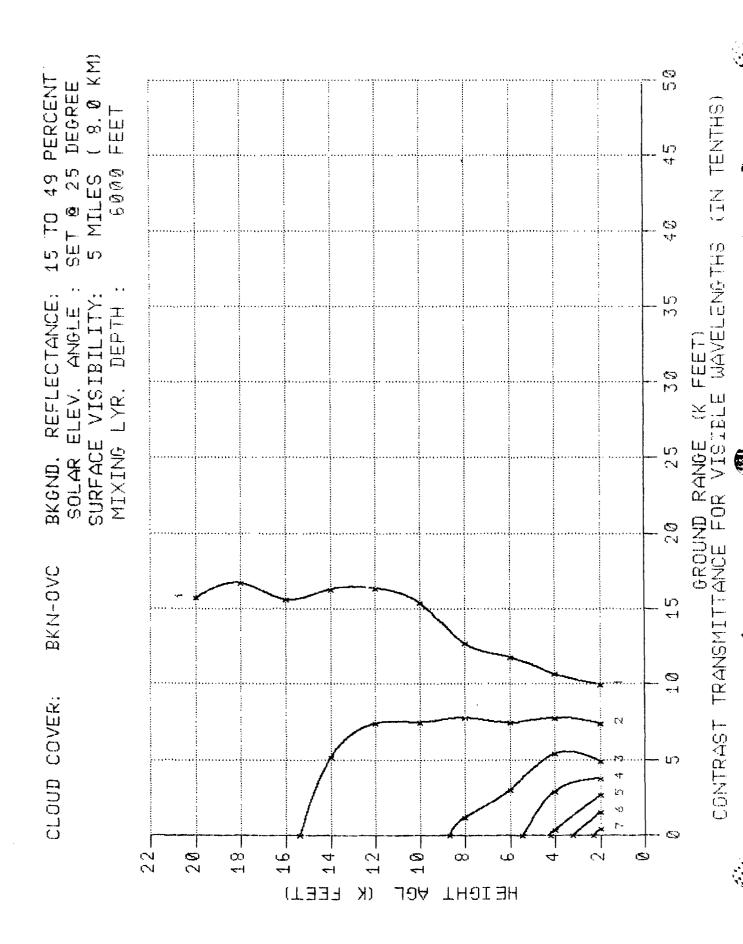
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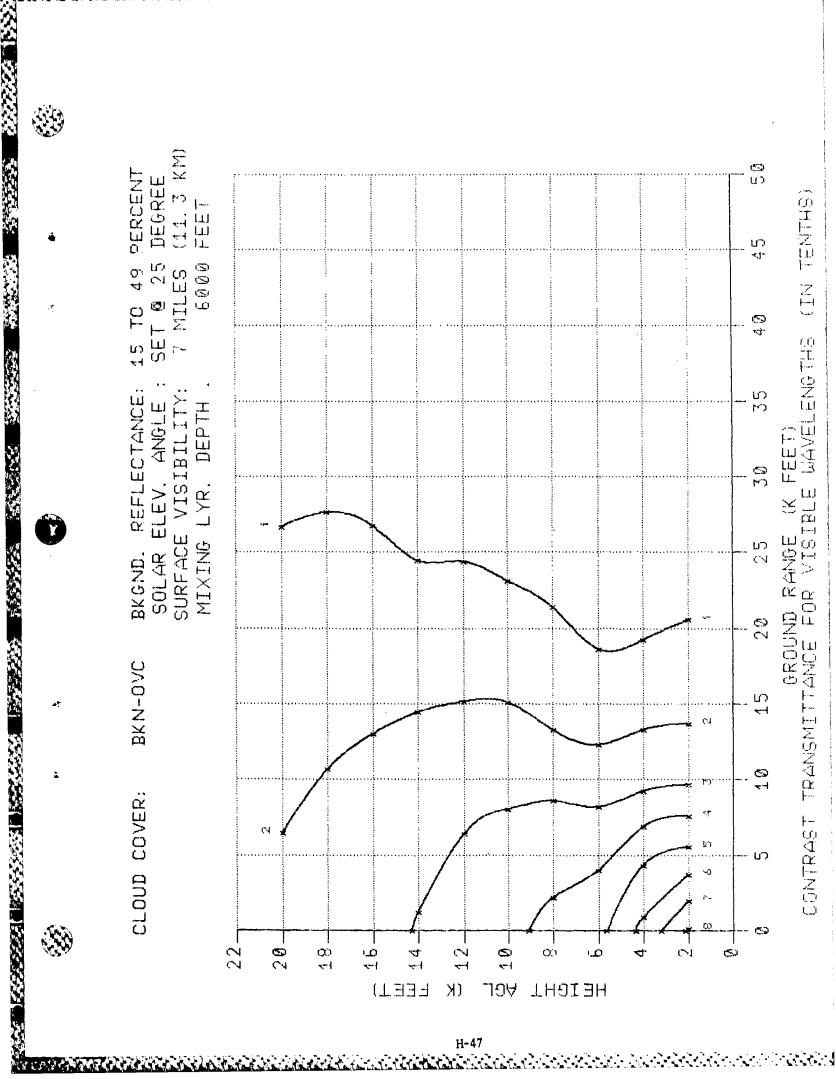


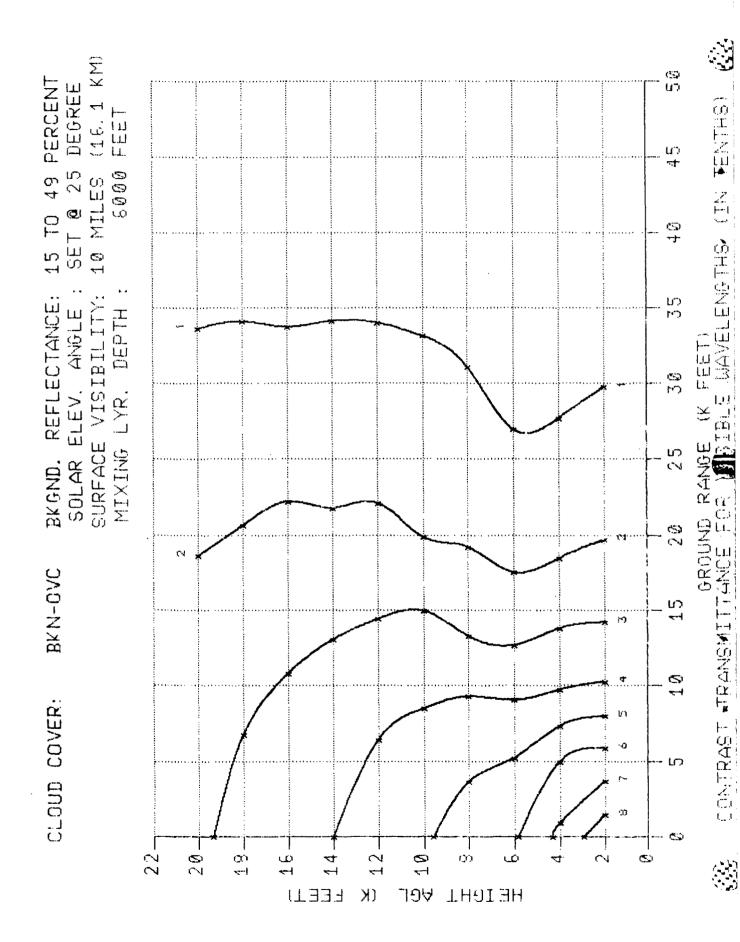




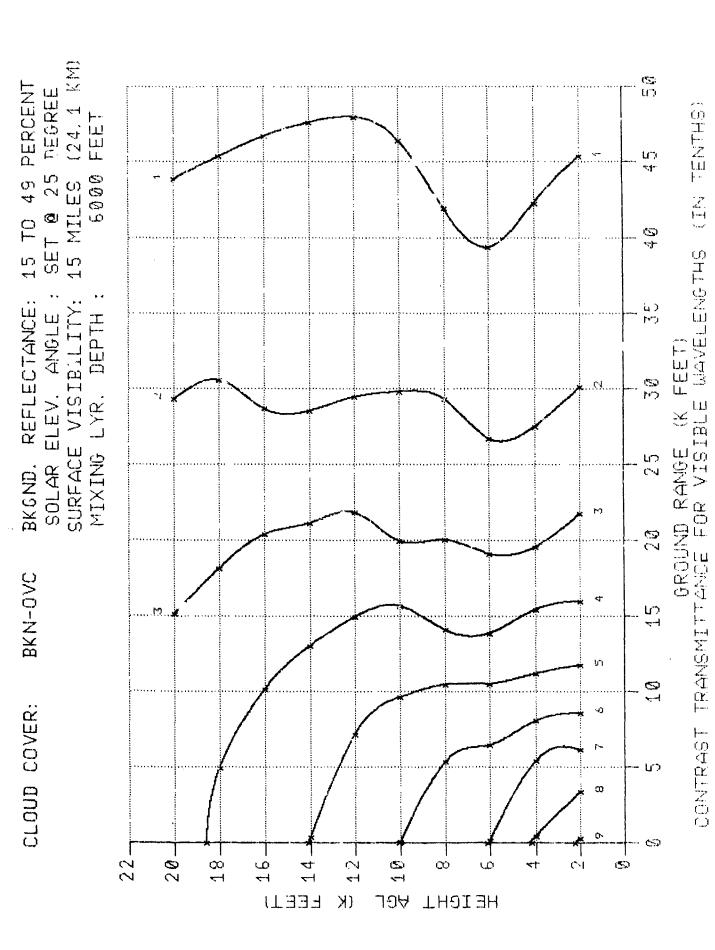
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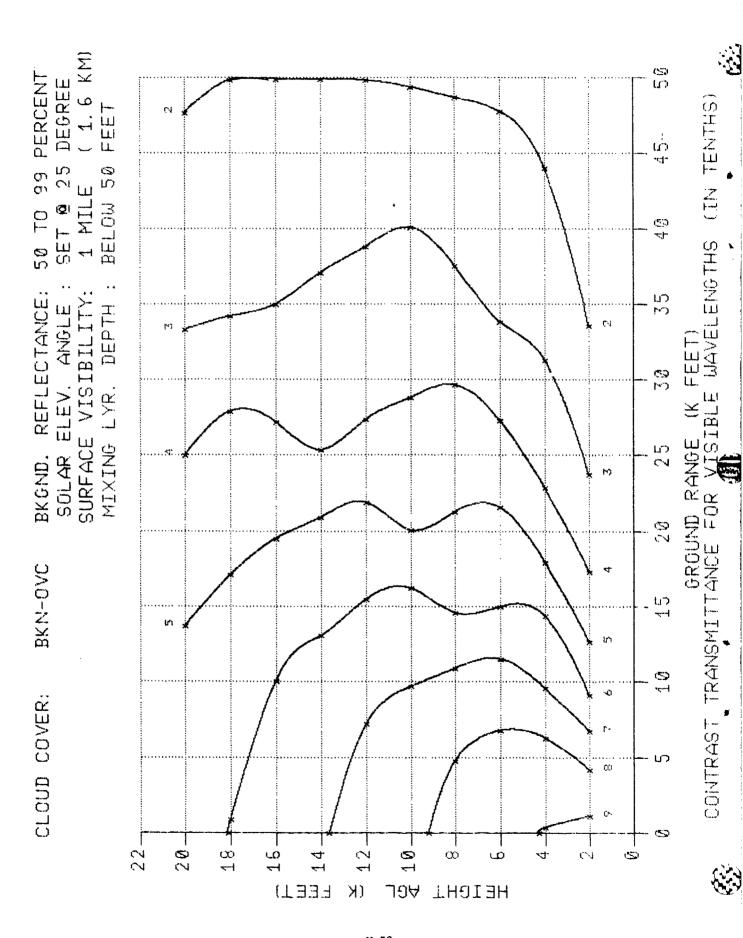




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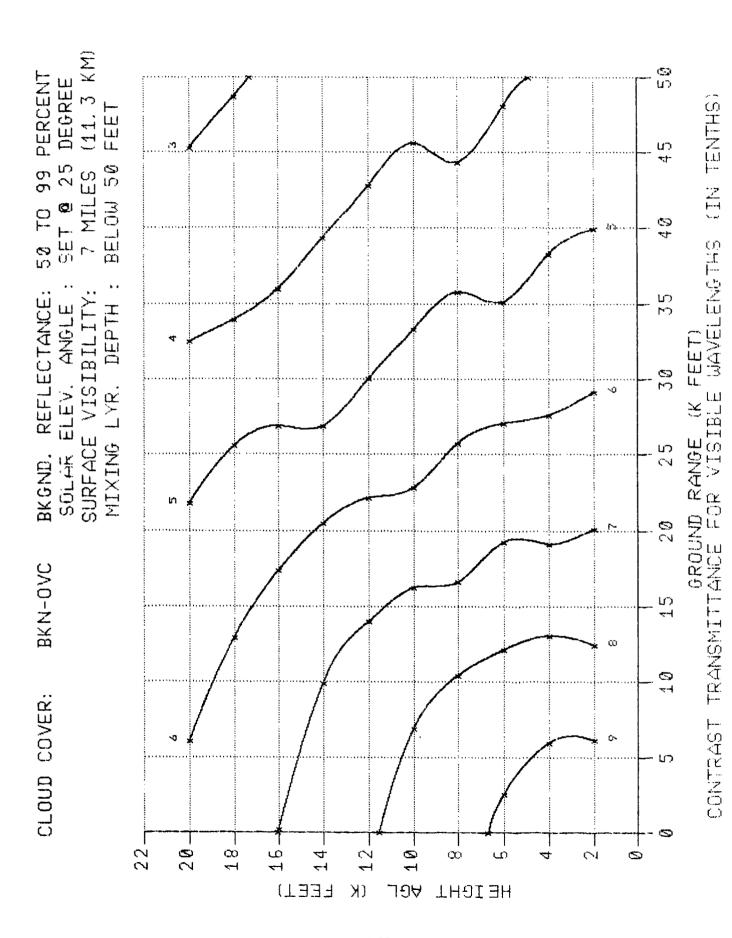
 $\frac{x}{2}$ (53) [(7) 99 PERCENT DEGREE GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) (4,8 FEET (1) T 50 TO 99 F SET @ 25 3 MILES 25 BELOW 50 S T SOLAR ELEV. ANGLE : SURFACE VISIBILITY: MIXING LYR. DEPTH : ന ന BKGND, REFLECTANCE: 8 S (S) BKN-0VC رم دع CLOUD COVER: 22 -20-<u>4</u> 8 ⊢ <u>21</u> 9 ₹-1 ₹1 12 40 7 တ **1**3 ഥ LEET) 79**∀** ίK

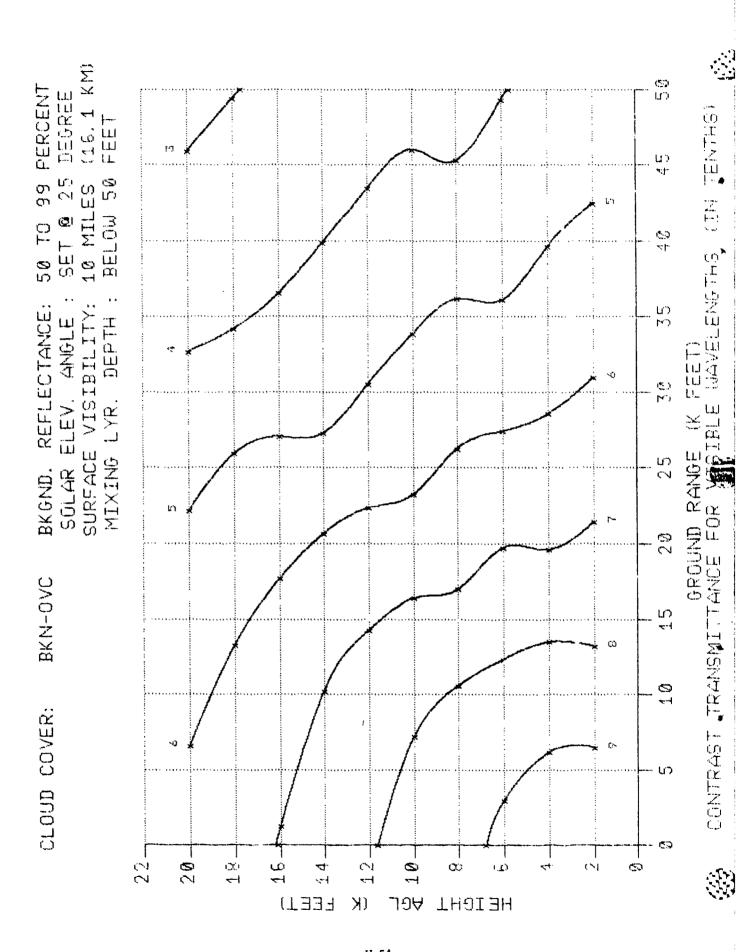
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 $\frac{2}{\Sigma}$ യ 99 PERCENT 25 DEGREE ® ∞ .0 GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) FEET BELOW 50 5 MILES SET @ 4. (2) REFLECTANCE: เก พว SURFACE VISIBILITY: SOLAR ELEV. ANGLE MIXING LYR. DEPTH 63 (11 BKGND. BKN-0VC CLOUD COVER: 20-101 8 16 22 7 122 တ ف **\***5 (3) LEEL) ٦Đ∀ ίK HEICHL

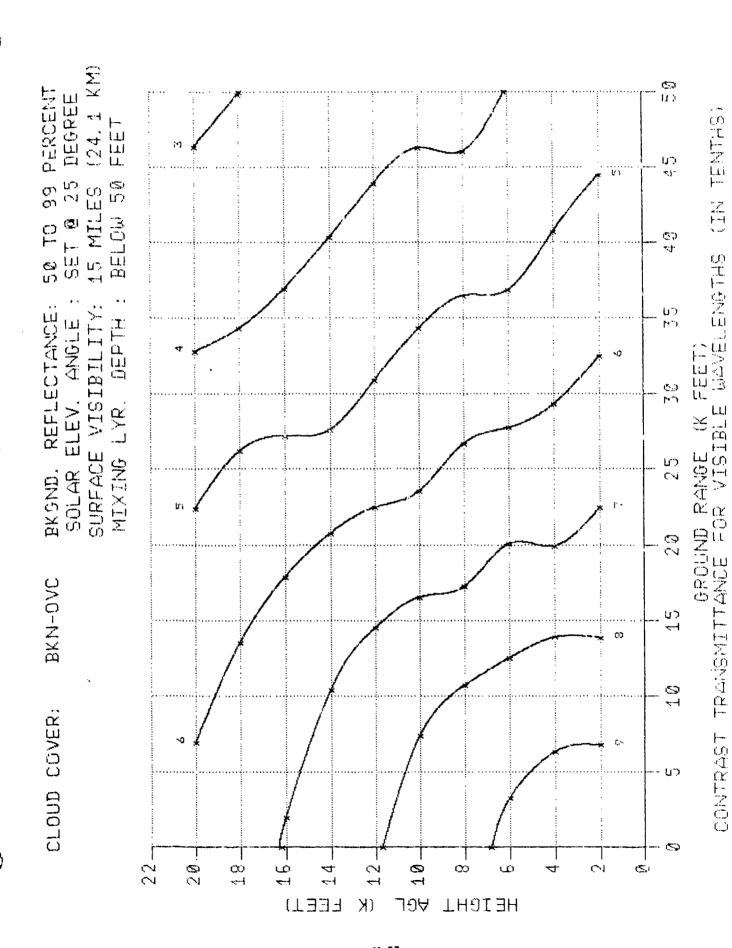
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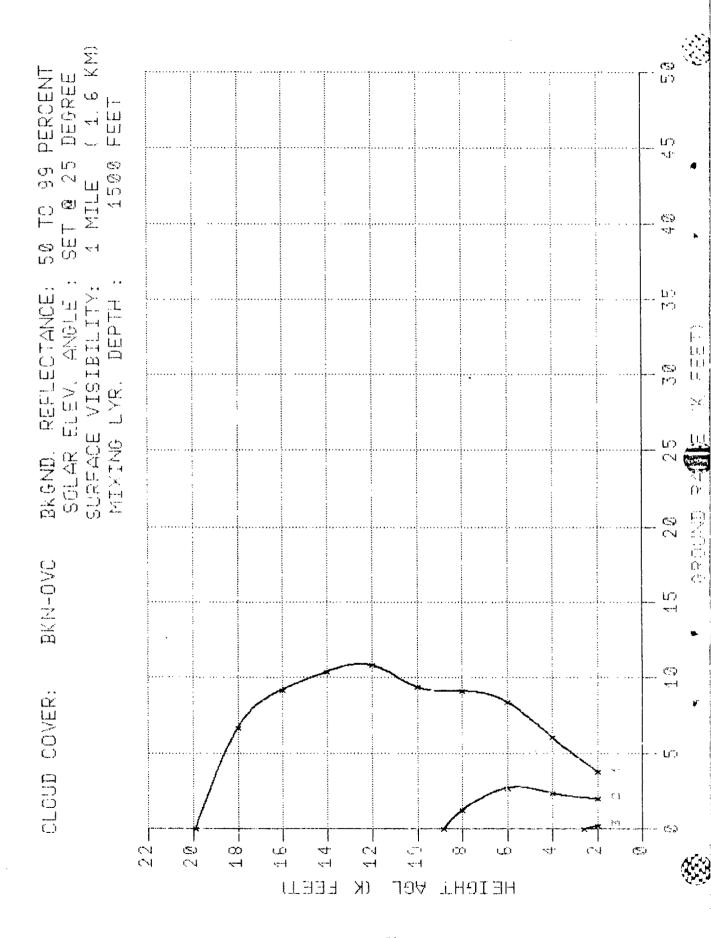
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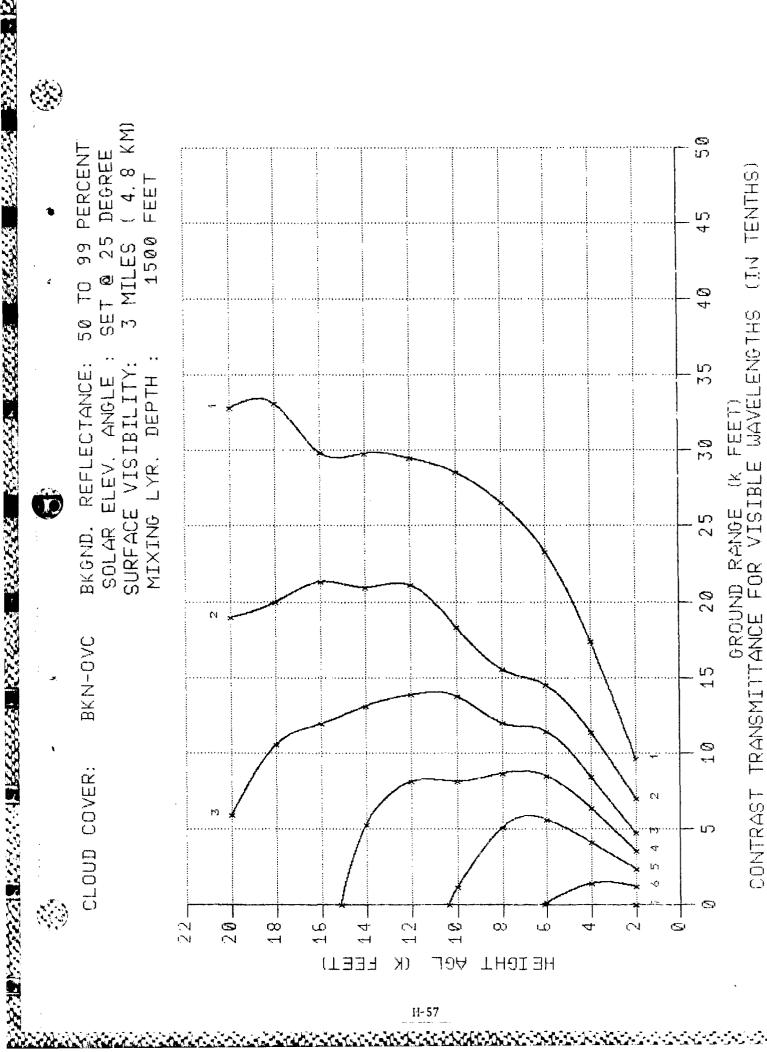
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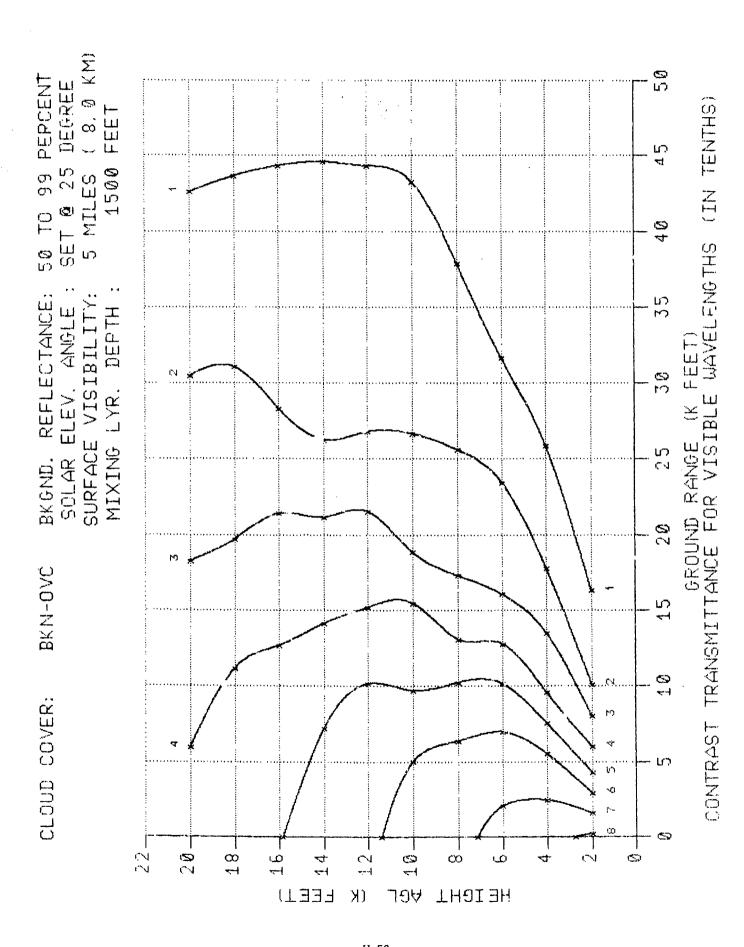


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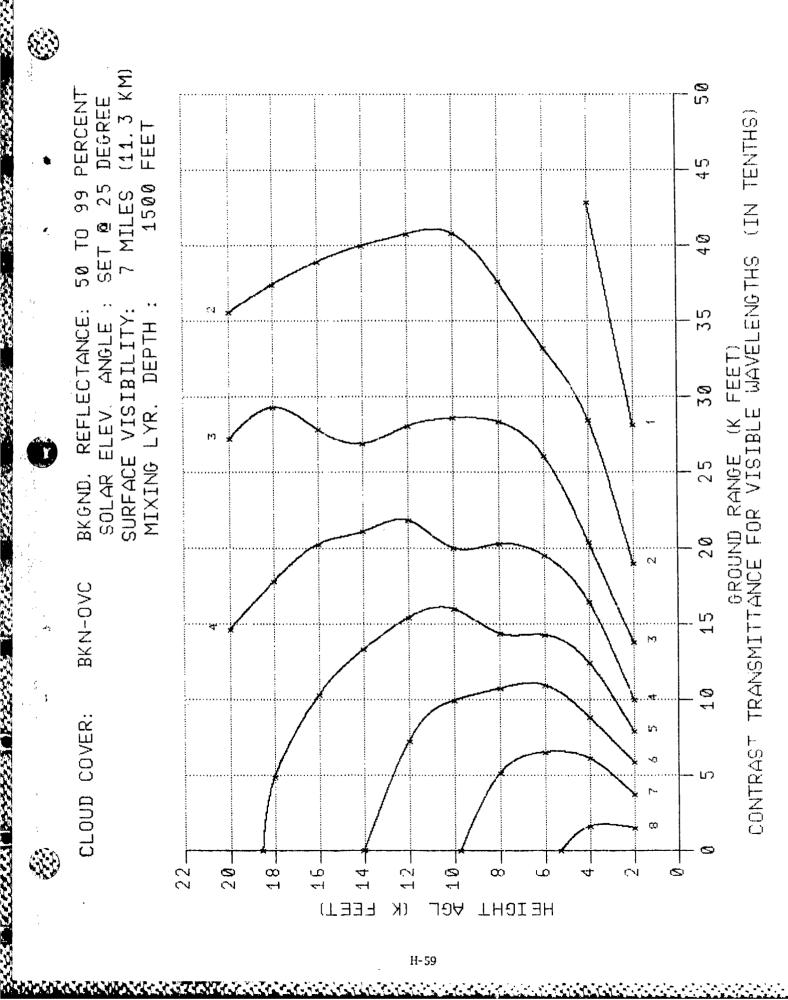
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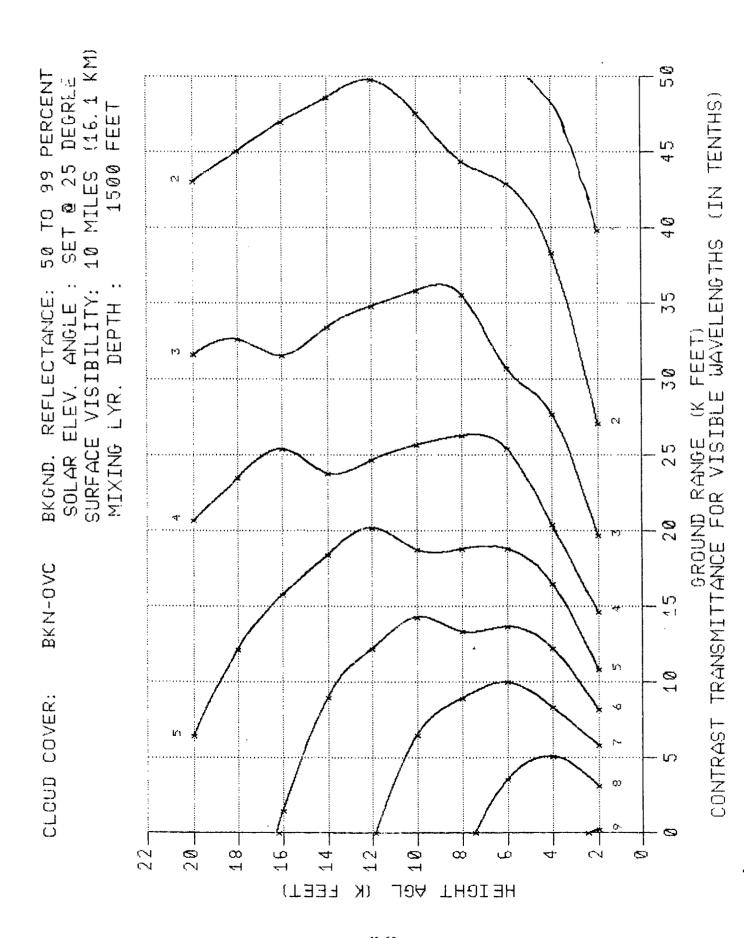
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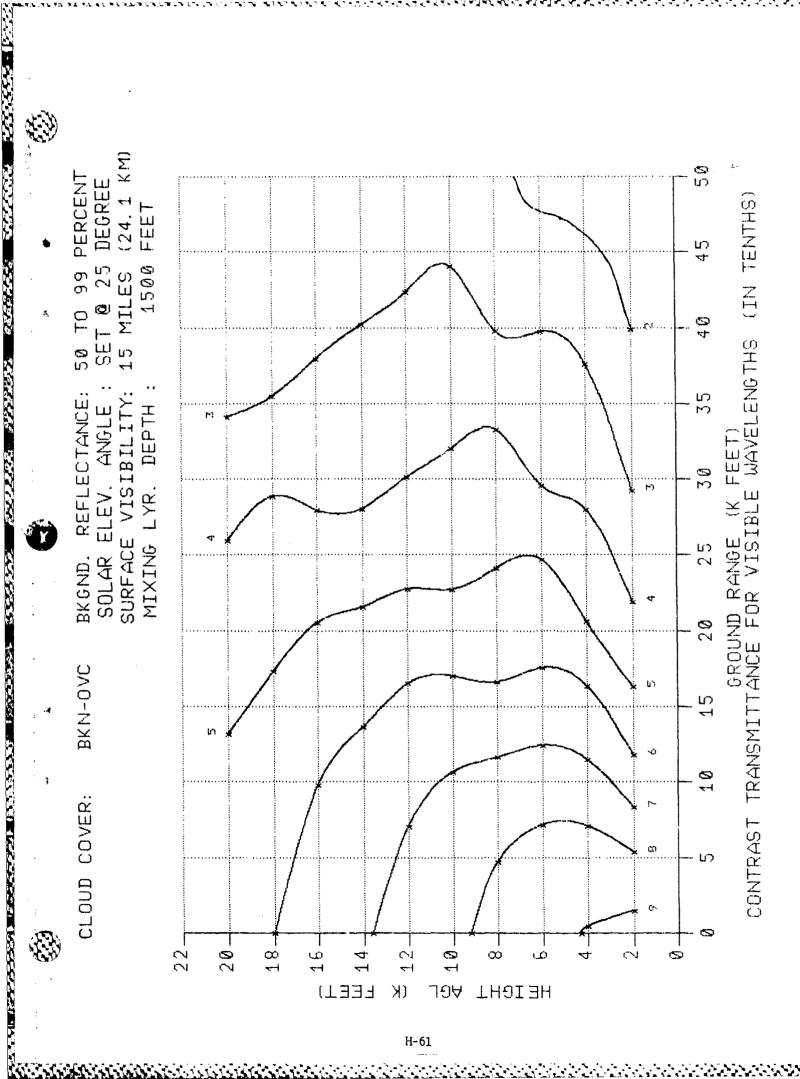


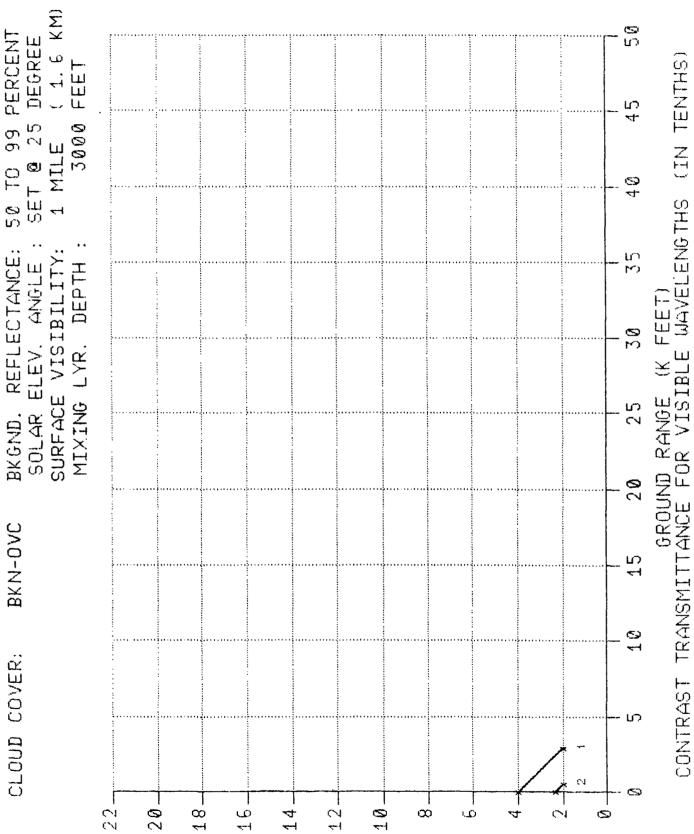
H-58





H-60



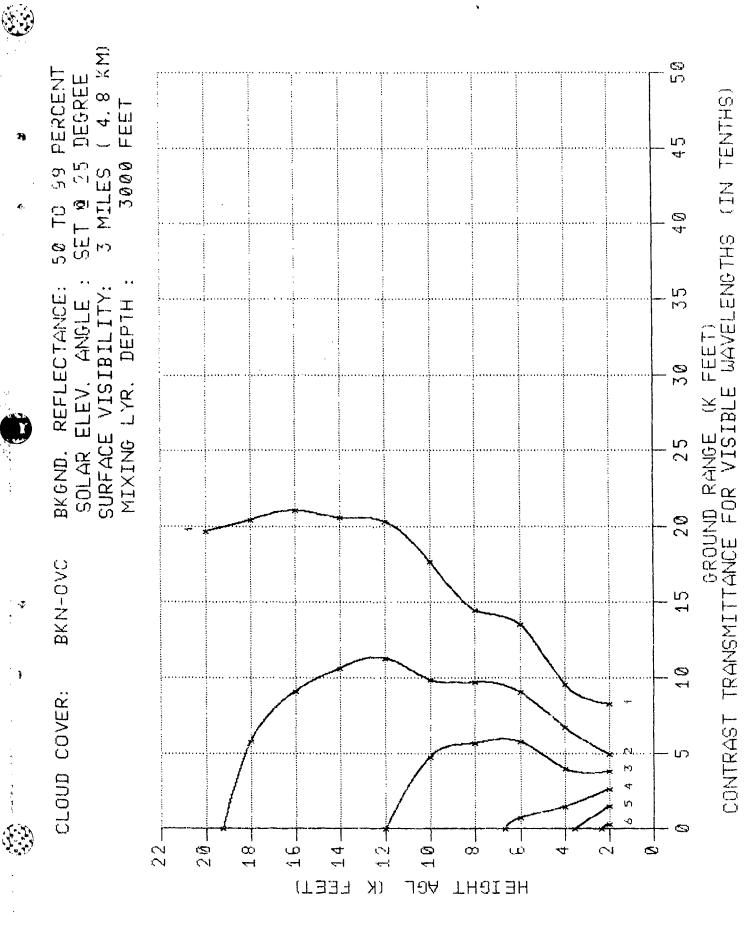


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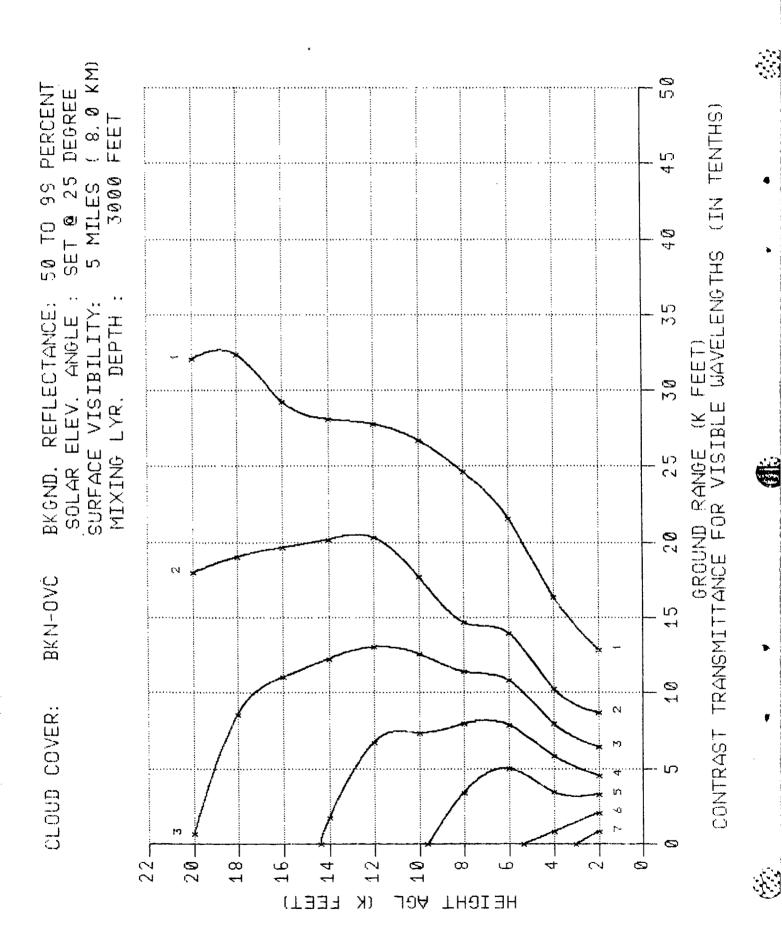
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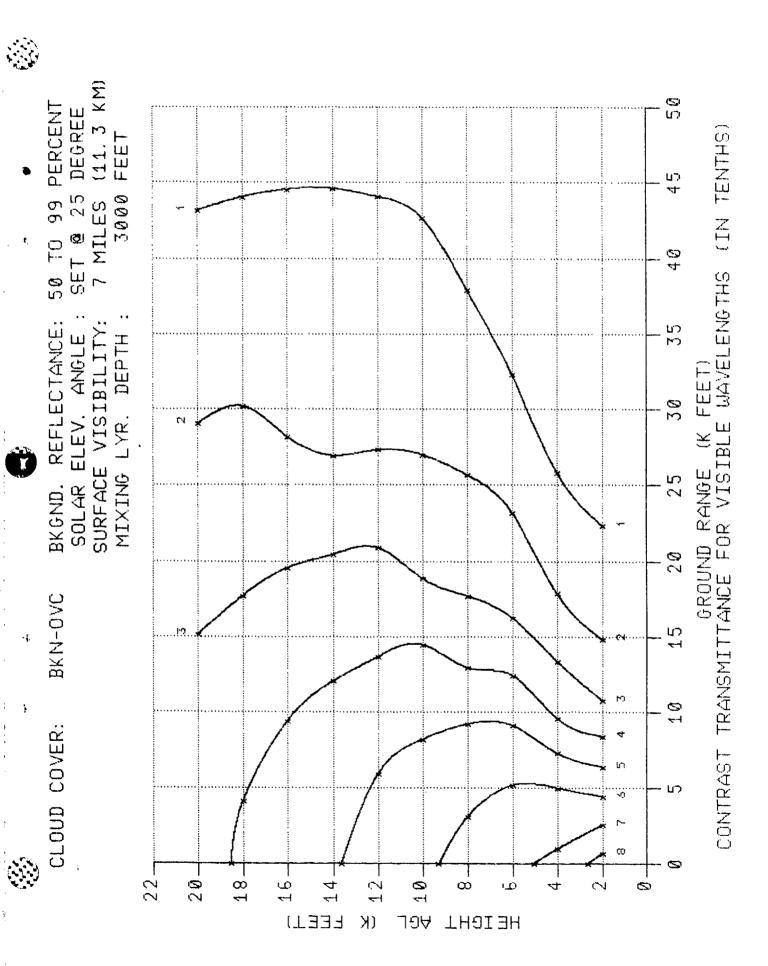
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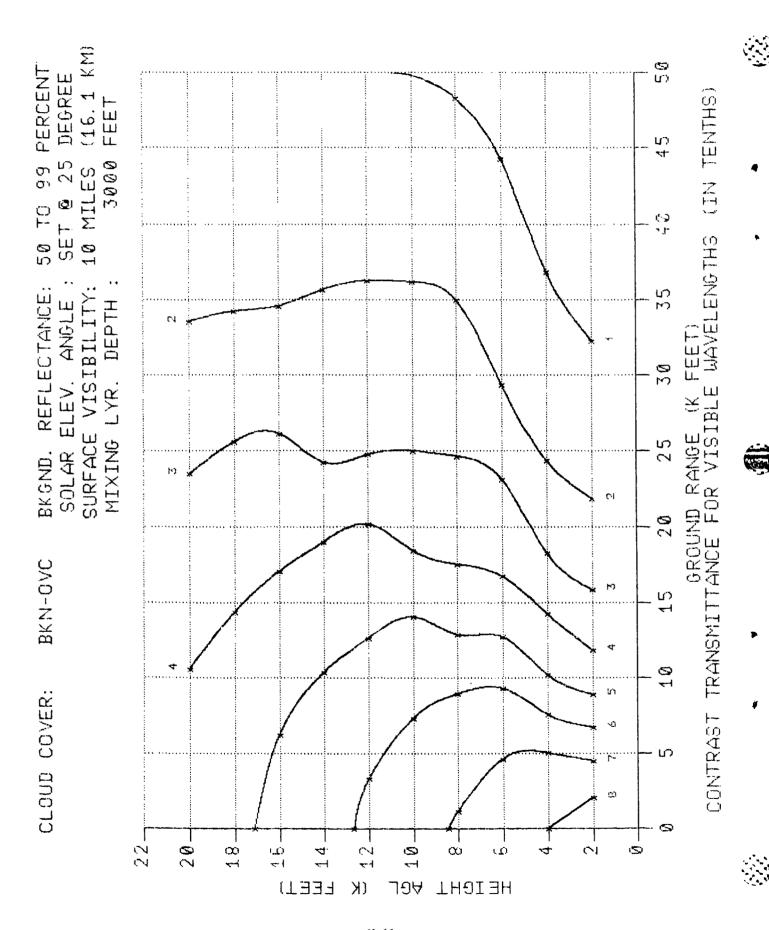


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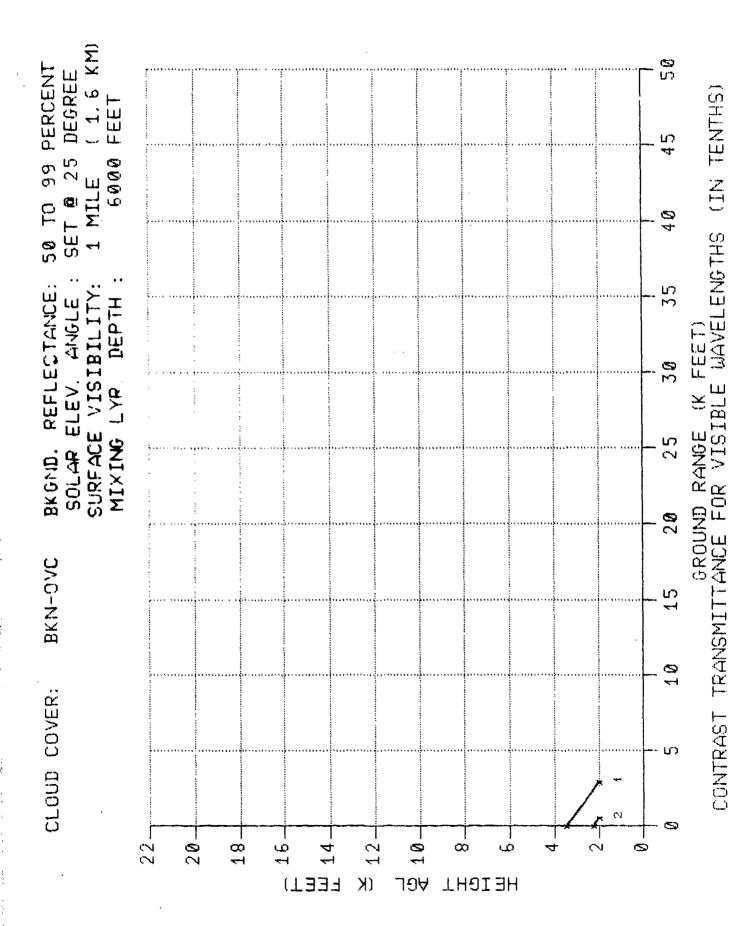


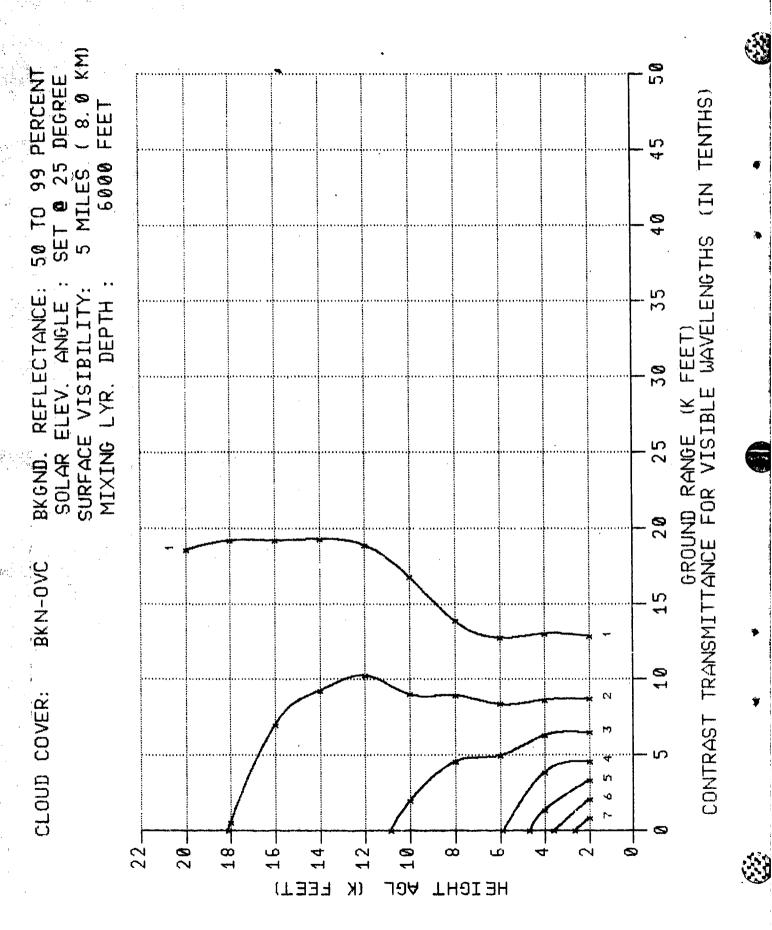


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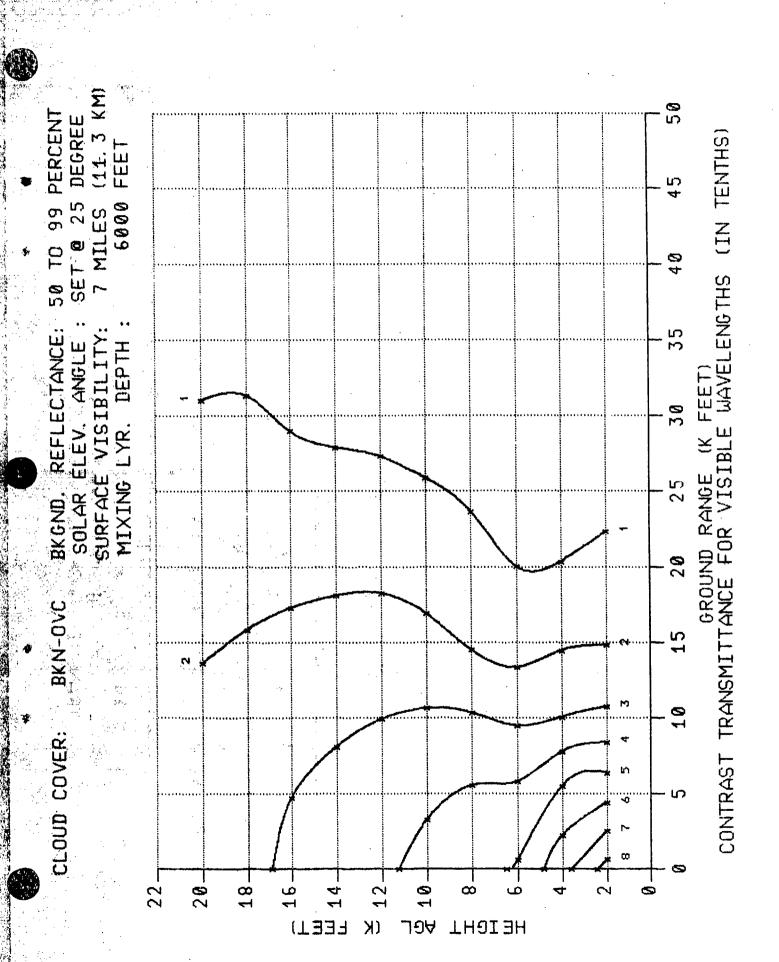


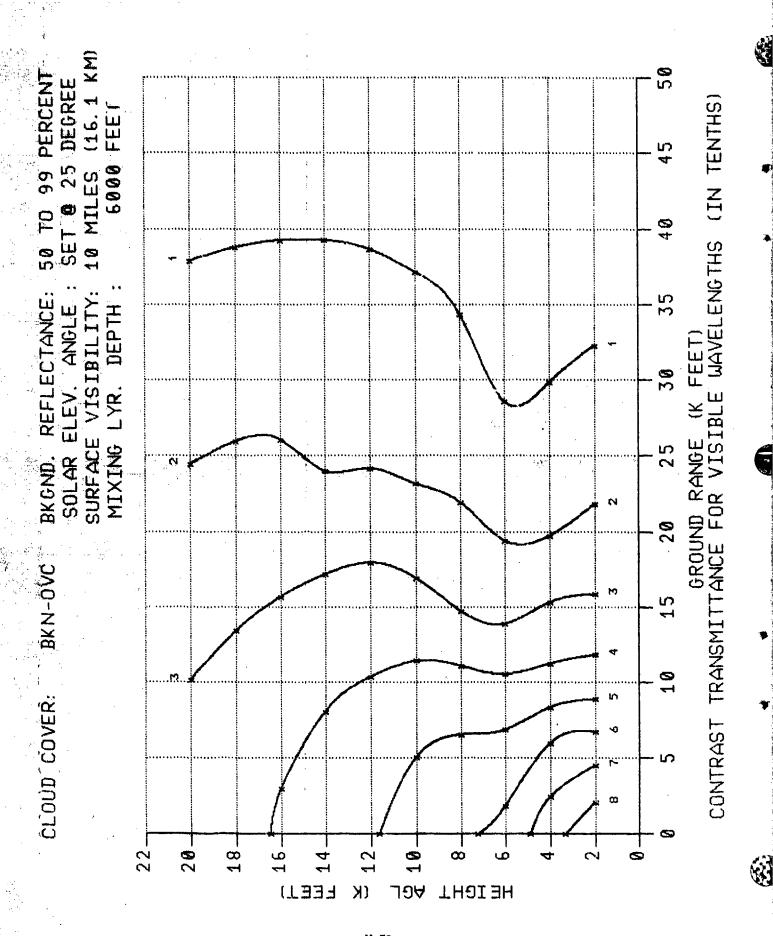
 $\sum_{i=1}^{\infty}$ وي (۱) PERCENT DEGREE (24.1 FEET 25 3000 თ თ 15 MILES SET @ 50 10 MIXING LYR. DEPTH : SURFACE VISIBILITY: REFLECTANCE: SOLAR ELEV. ANGLE GROUND RAMBE AT CONTRAST TRANSMITTANCE FOR VISIBLE BKGND. BKN-0VC 5 40 CLOUD COVER: 00 ĿΊ W 227 20-10-۵ S 18 <del>ا</del>  $\infty$ 14 ₹ LEET) (K 19∀ HE ICHT



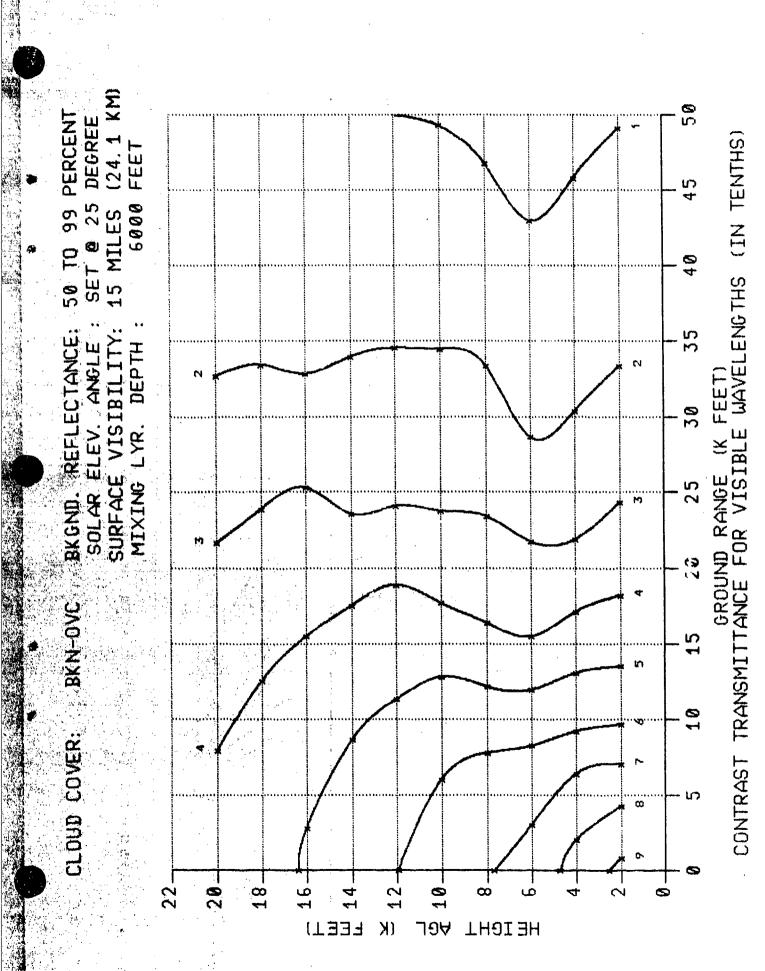


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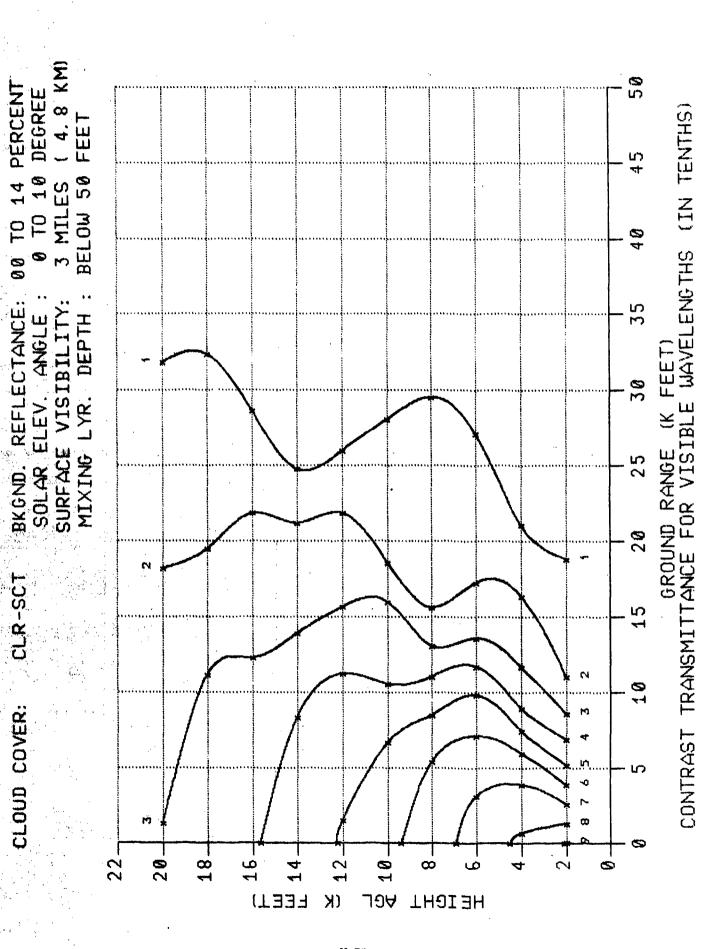
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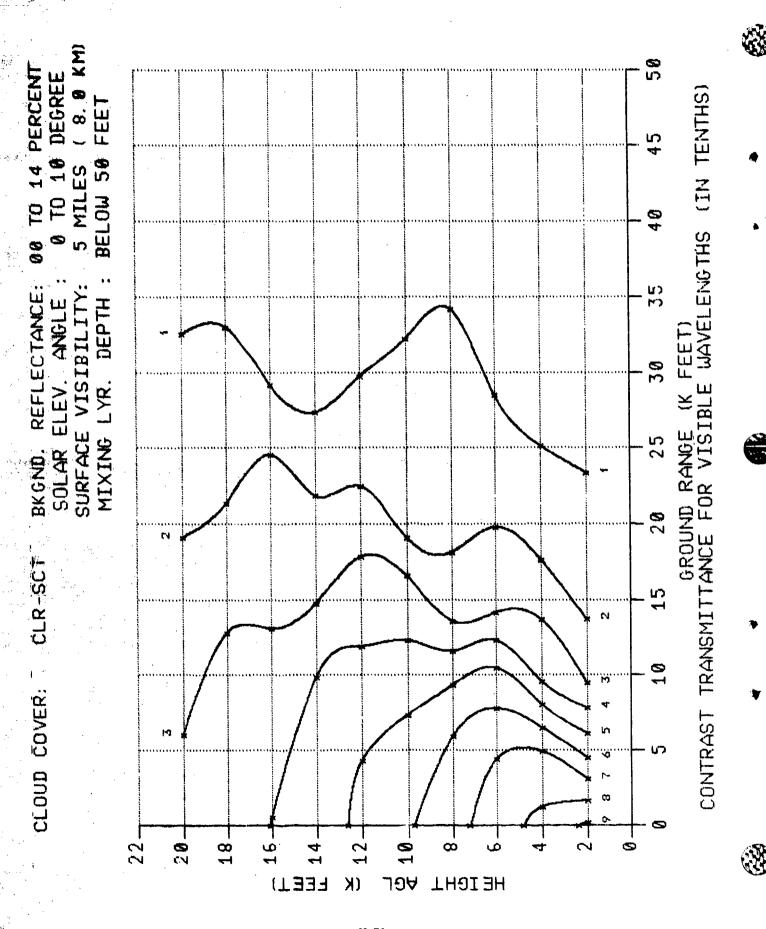
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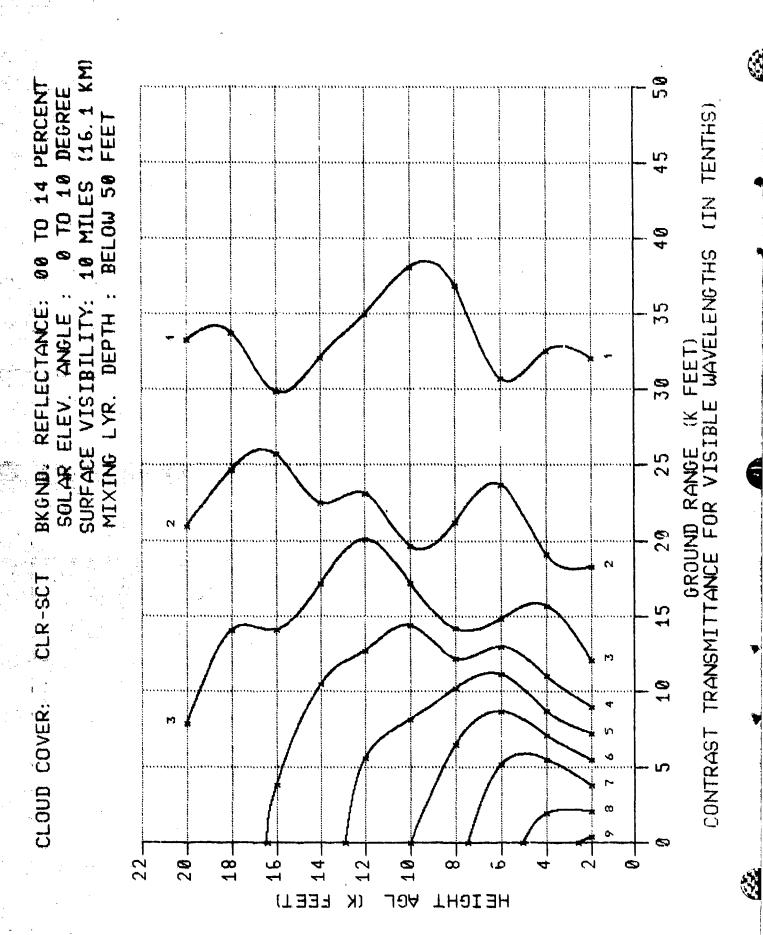
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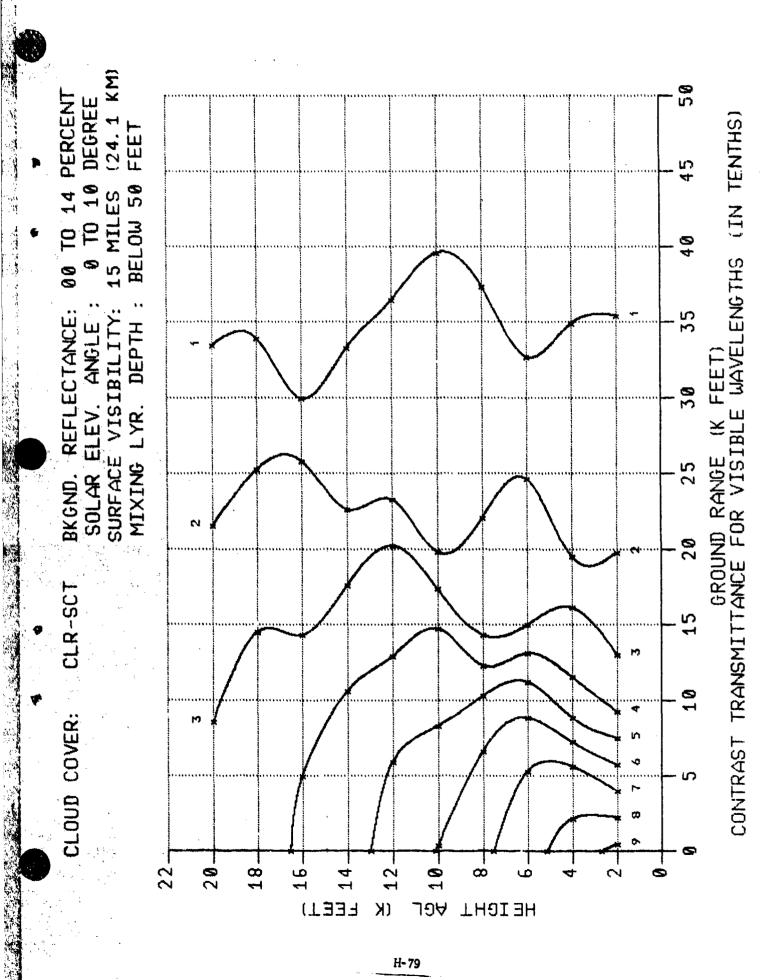
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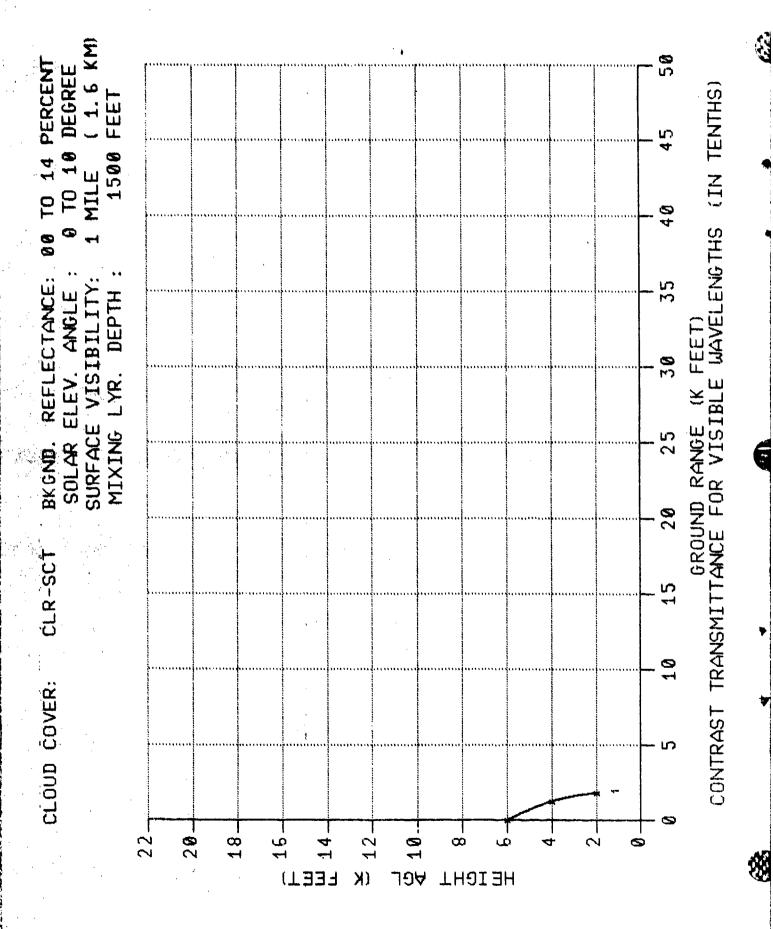
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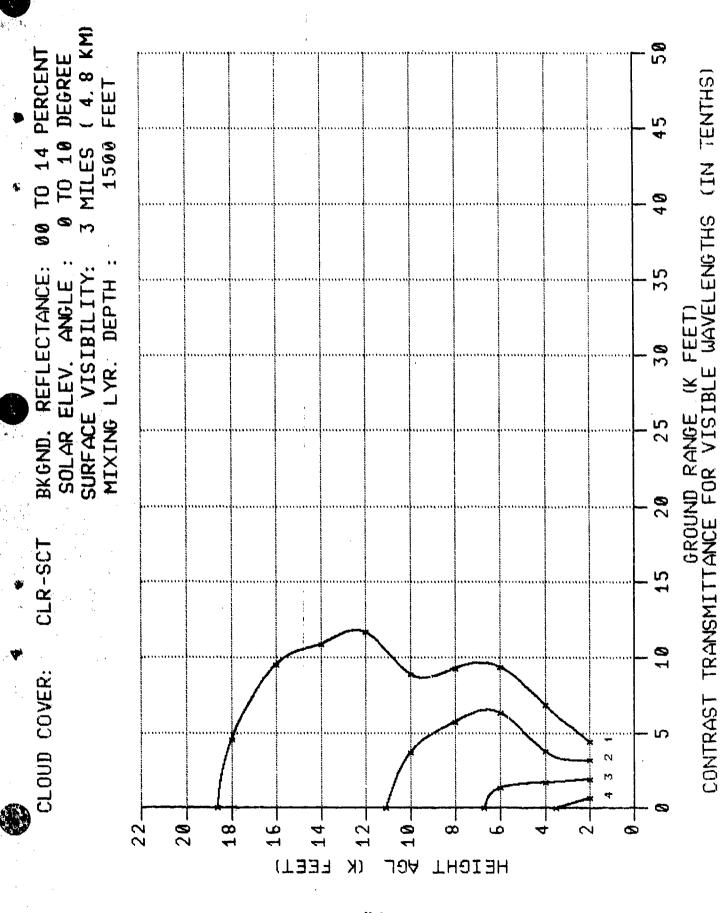
H-78



H- 79

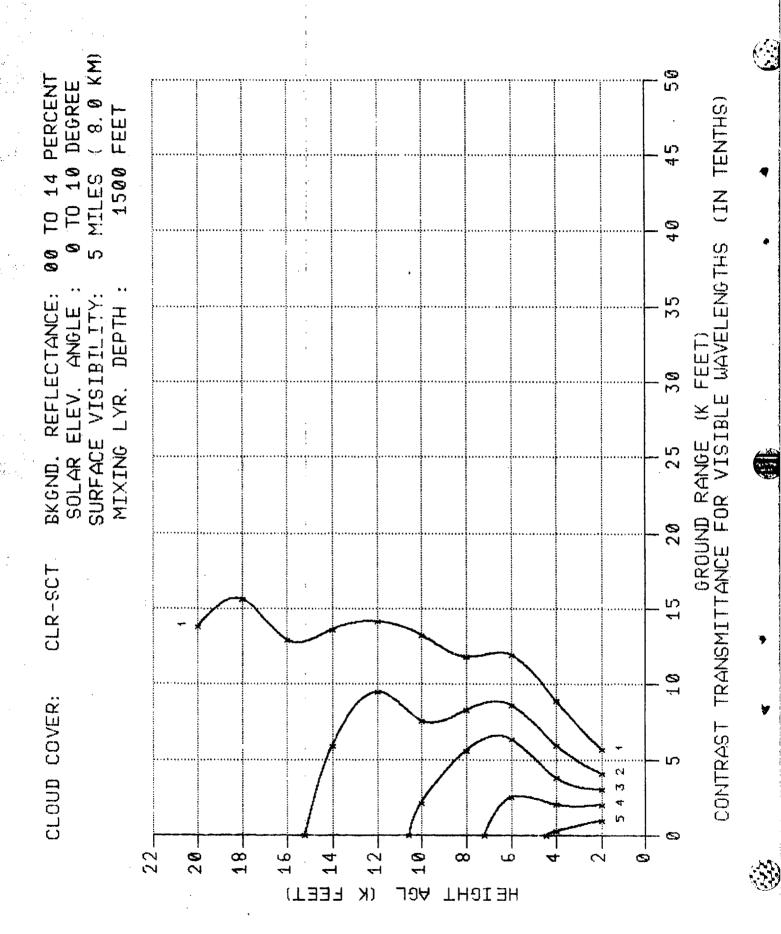


H-80

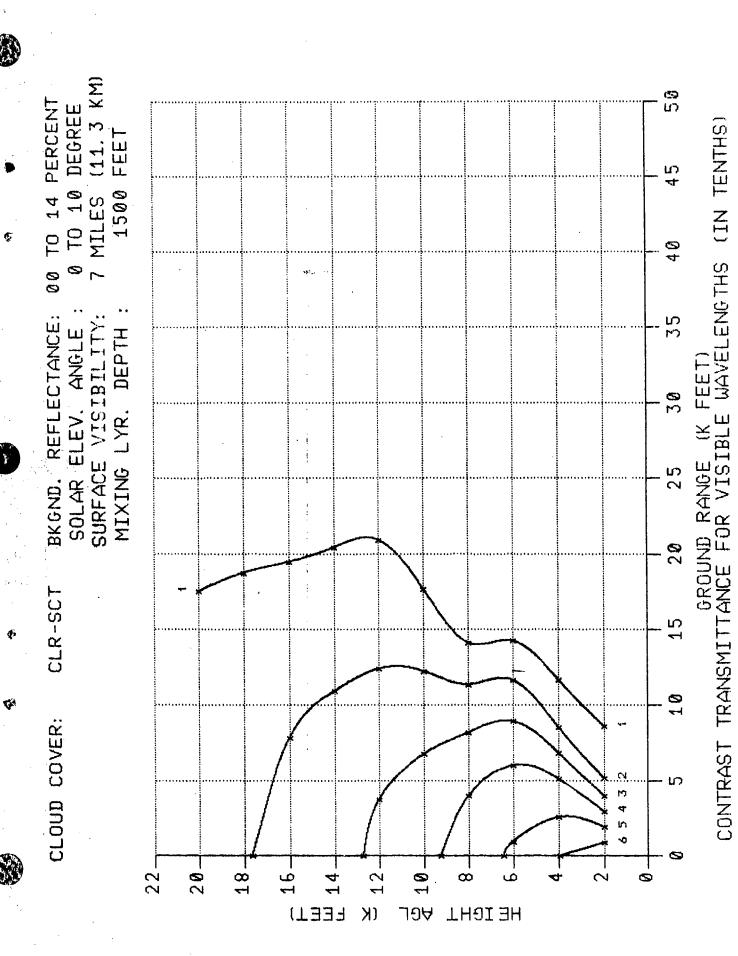


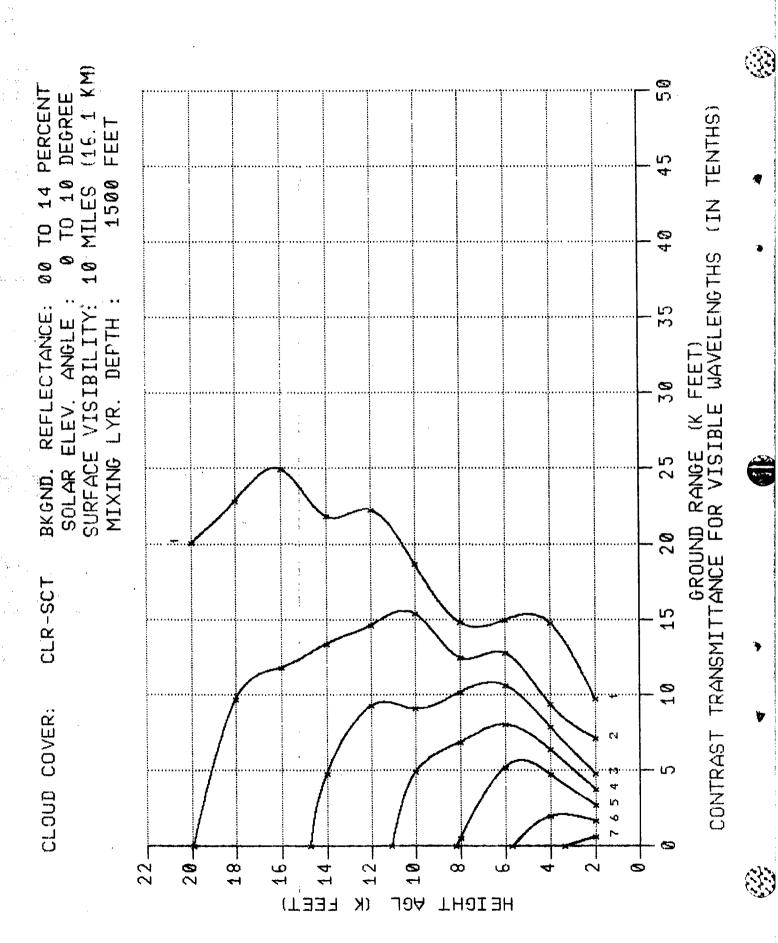
で、これが特別の対象による。そのでは、これには、はは、ないのでは、

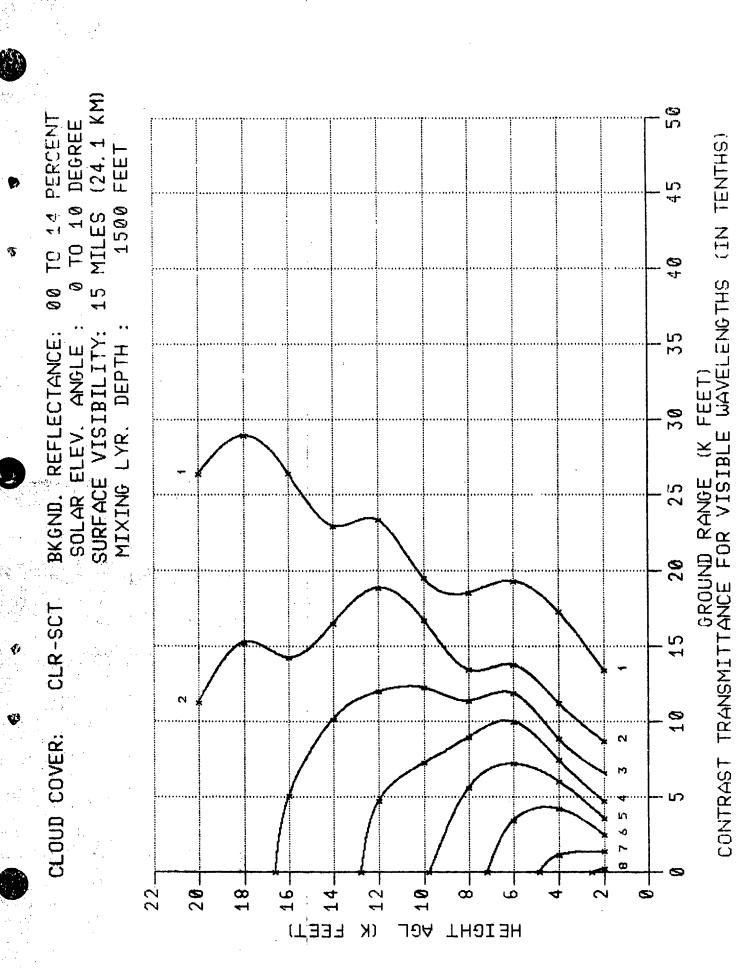
H-81



H-82

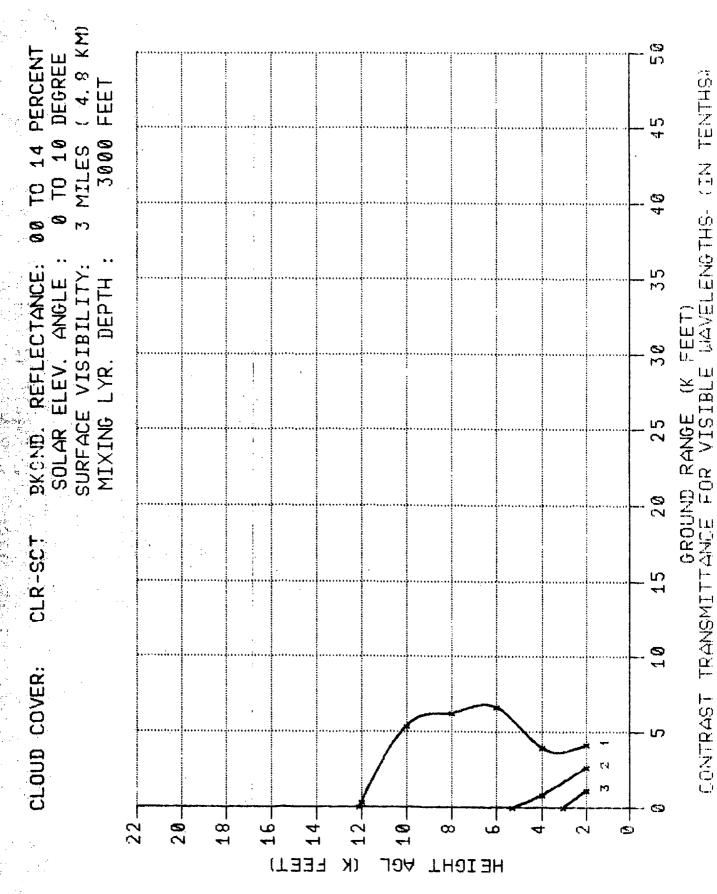




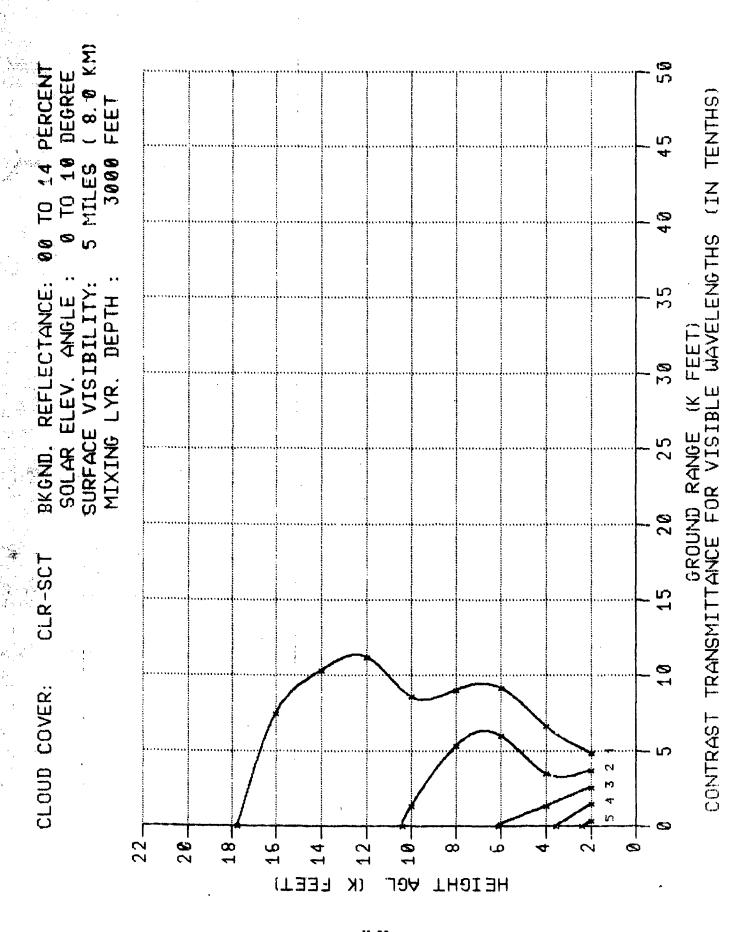


H-85

H-86

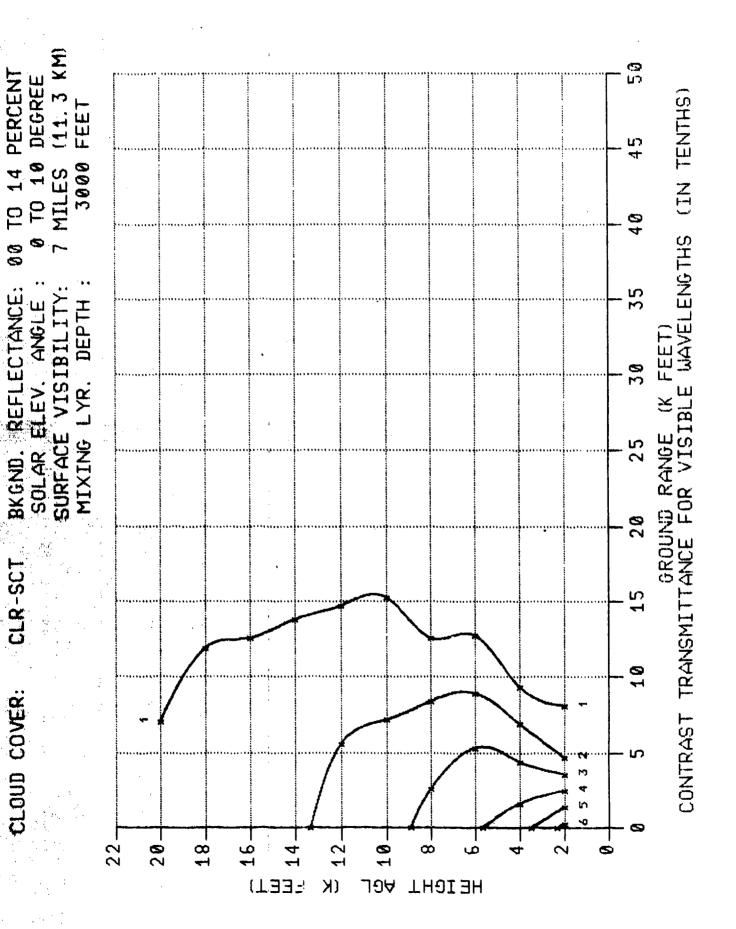


H-87

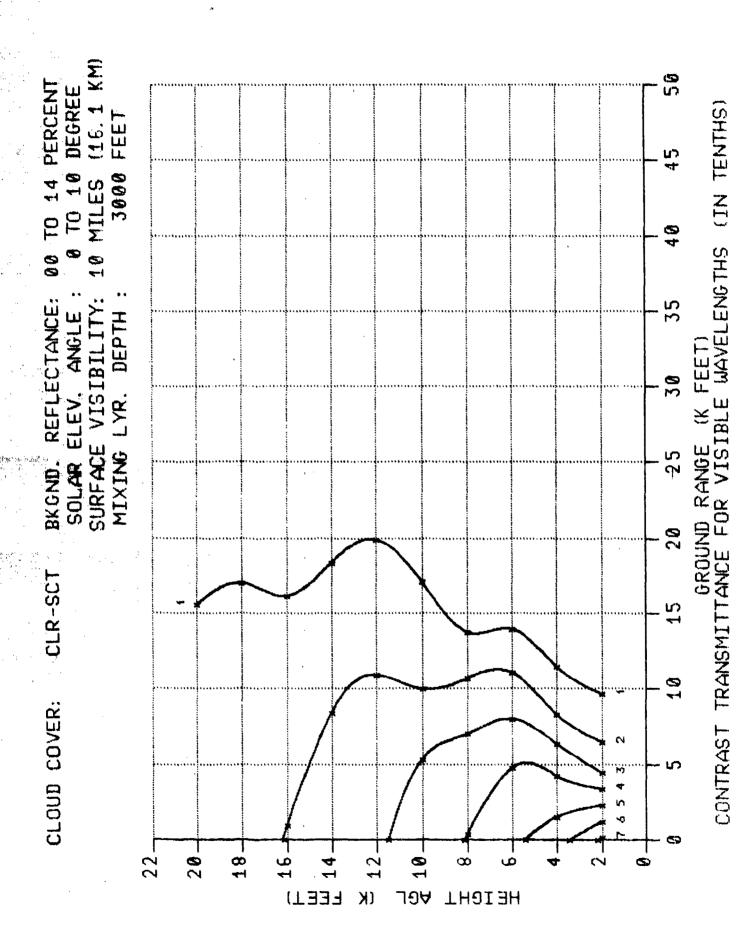


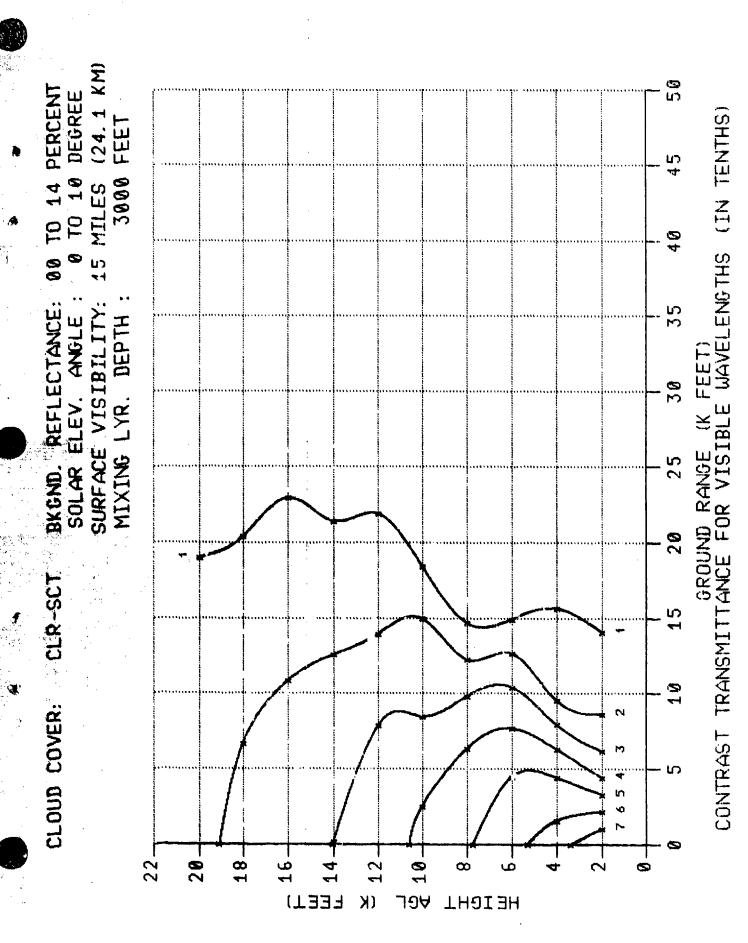
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H-88

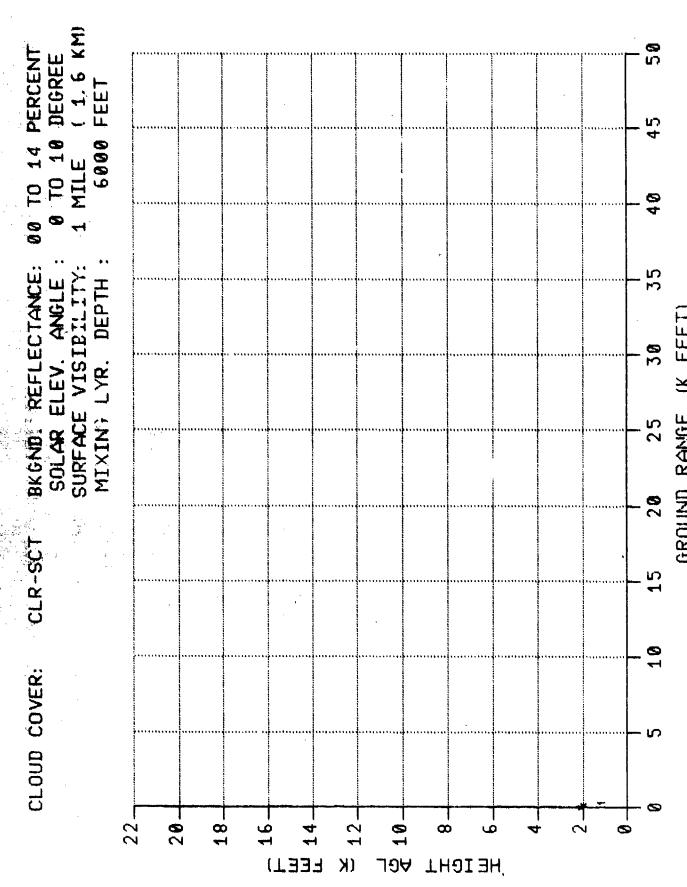


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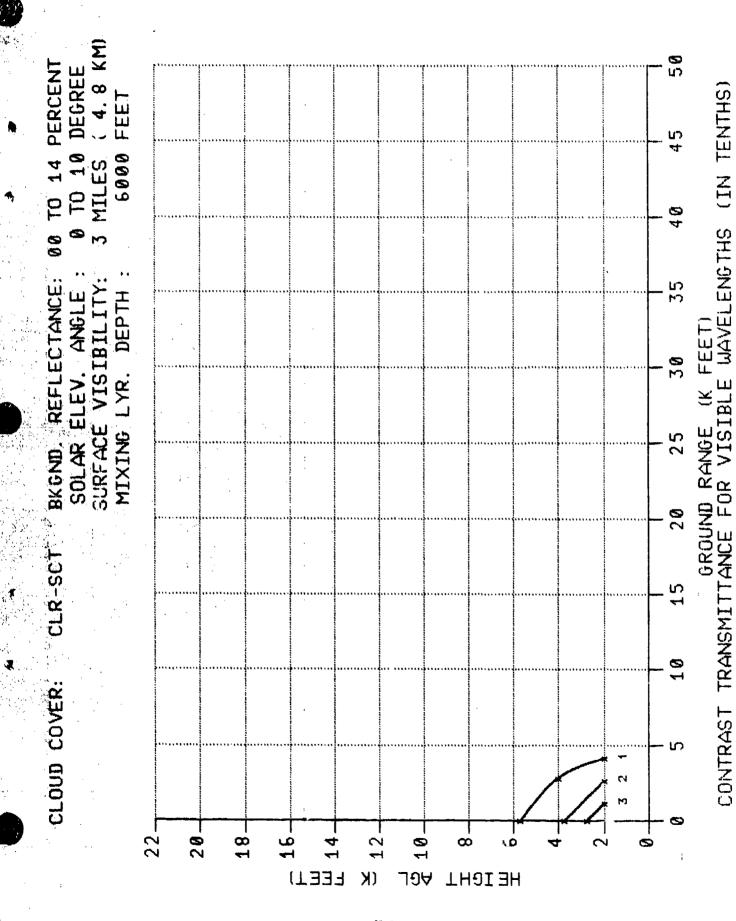
H-91



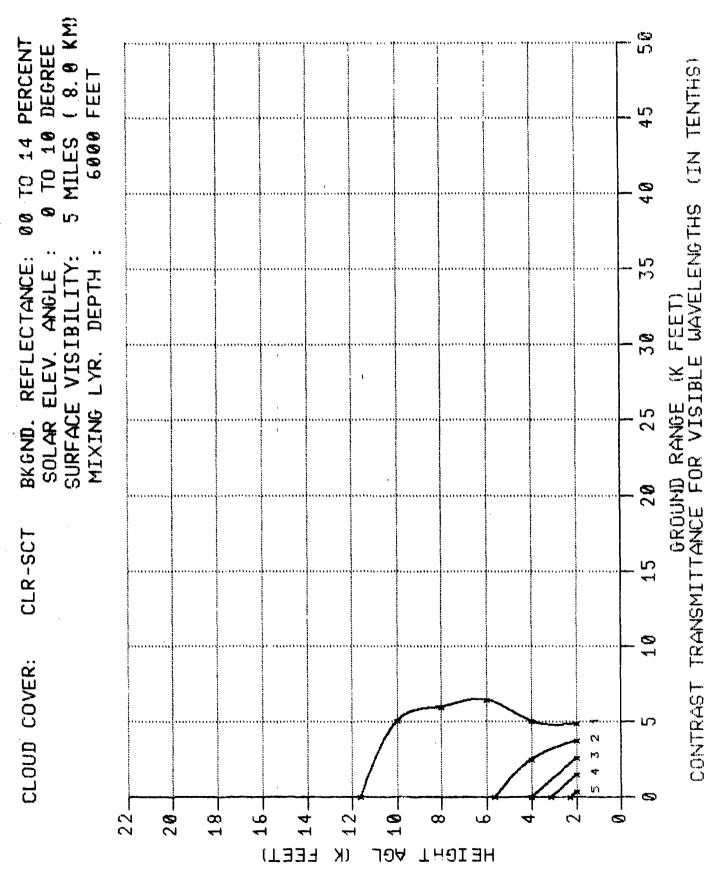
H-92

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

(1)



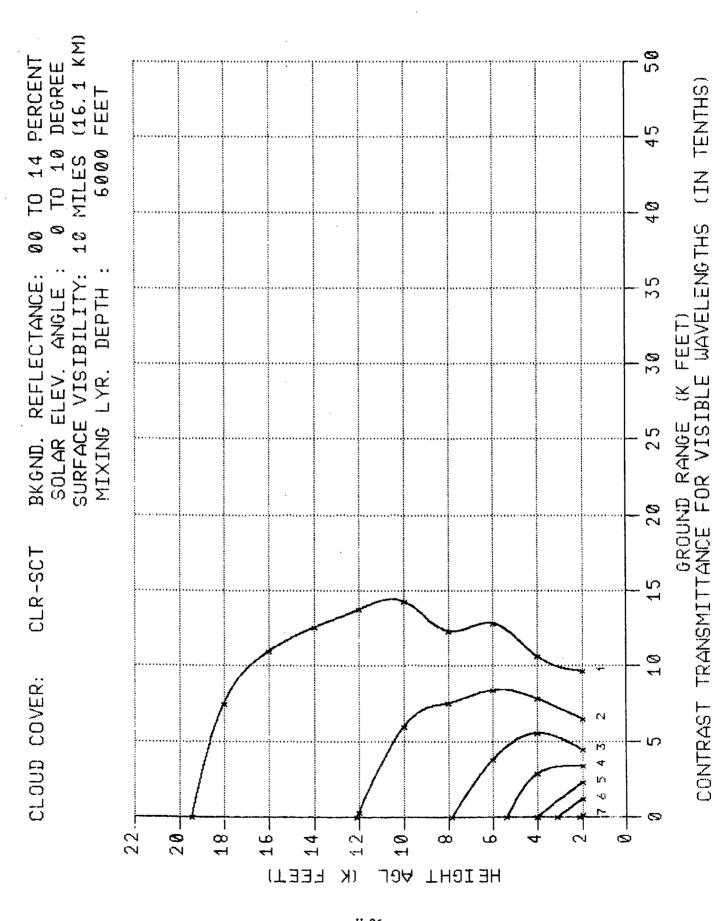
H-93

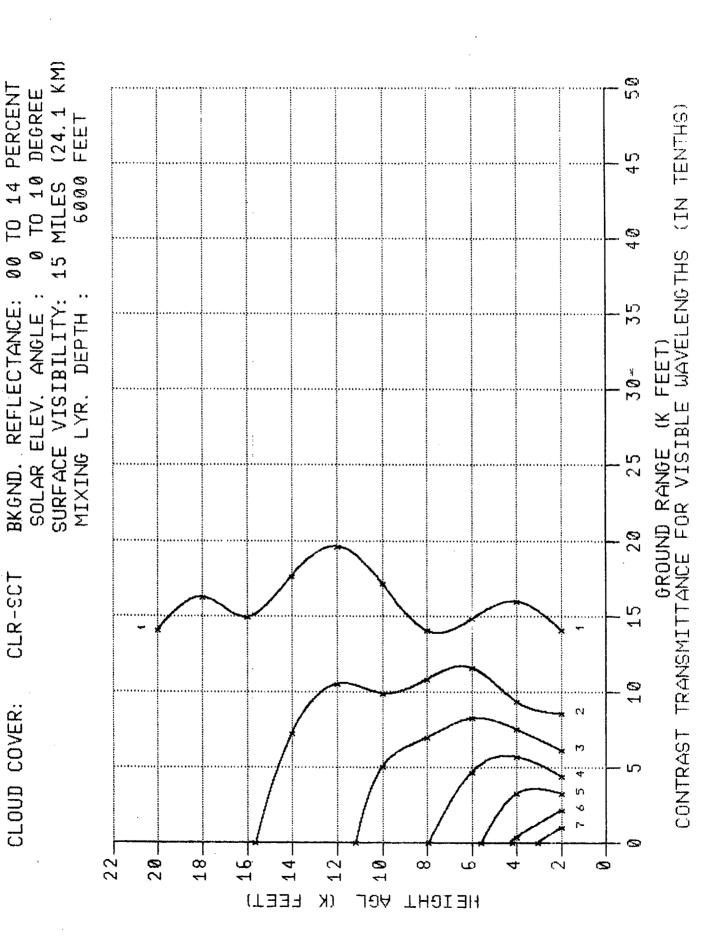


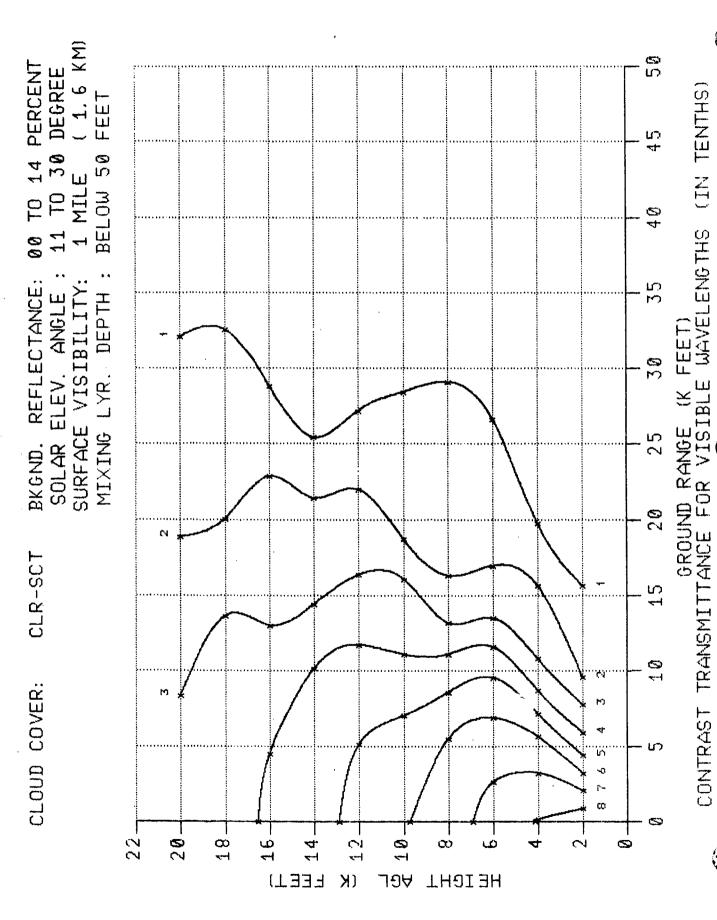
H-94

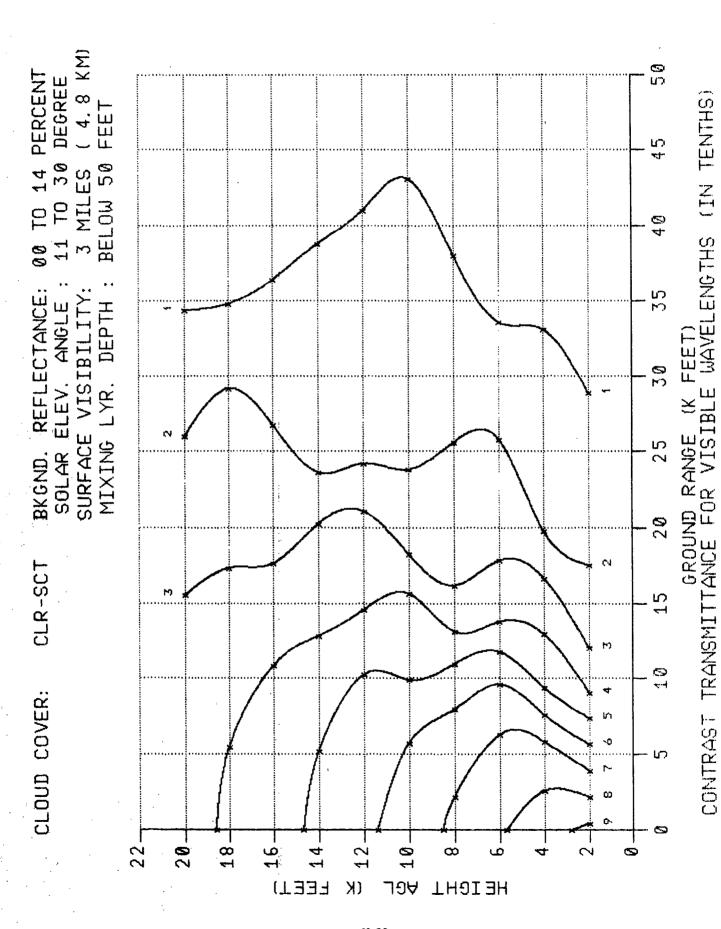
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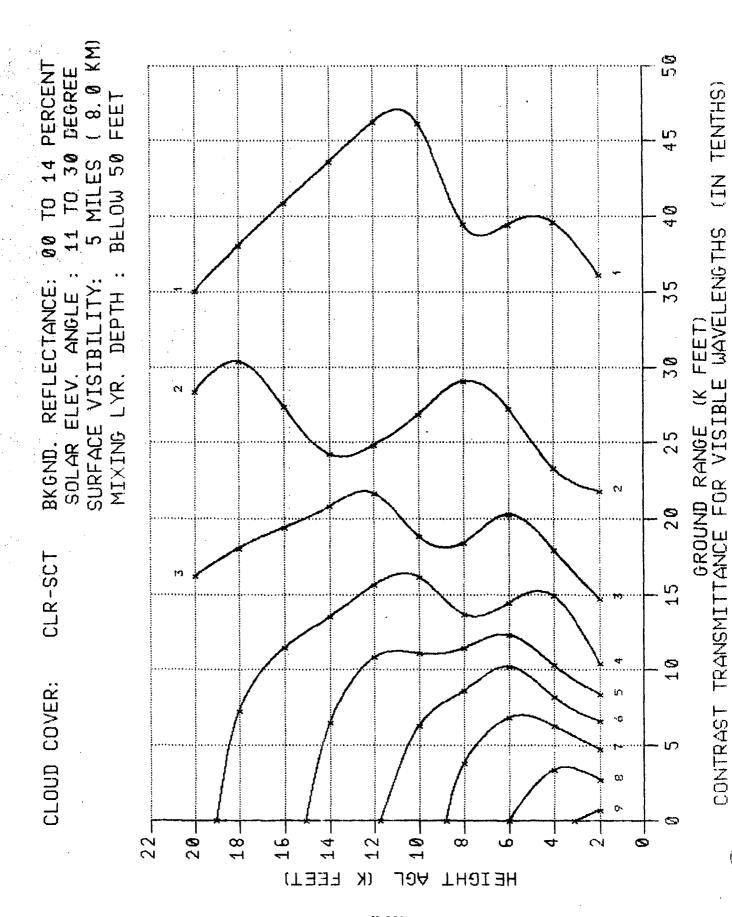




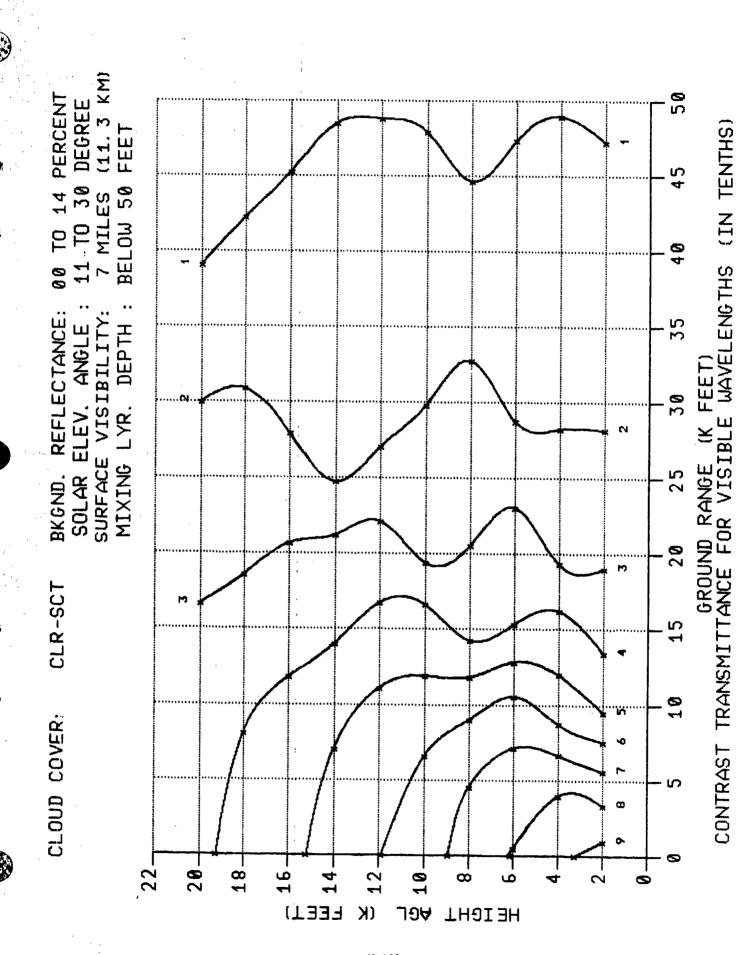




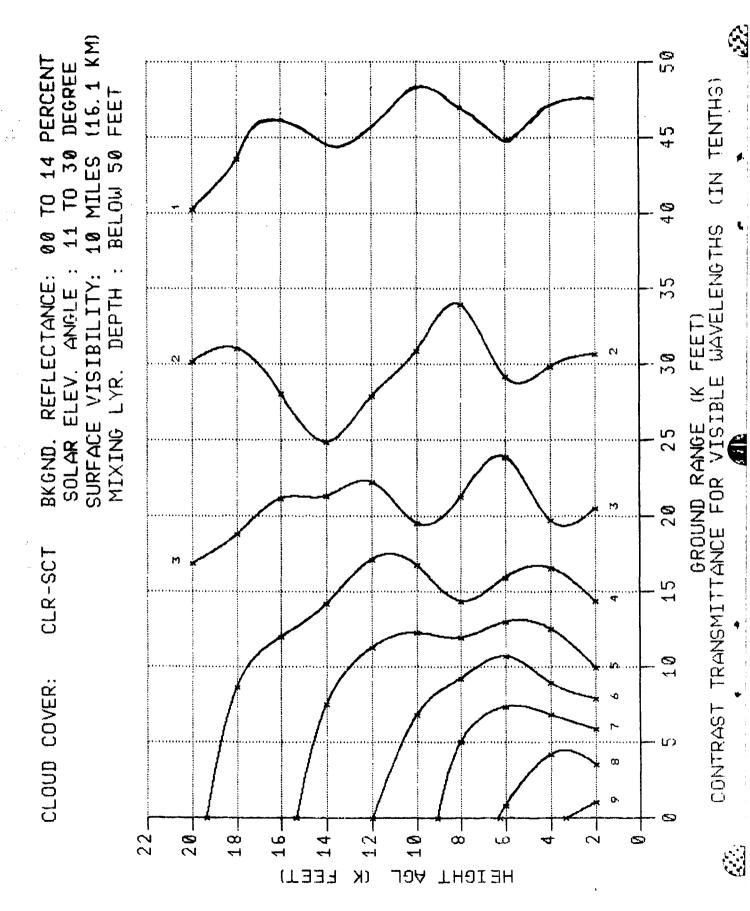
H-99



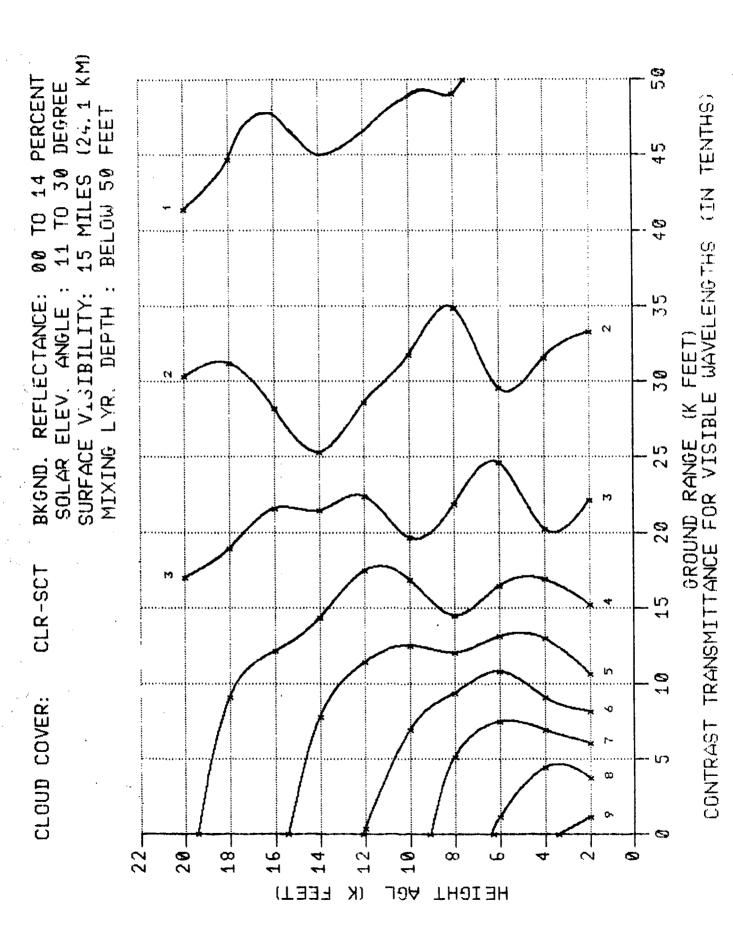
H-100



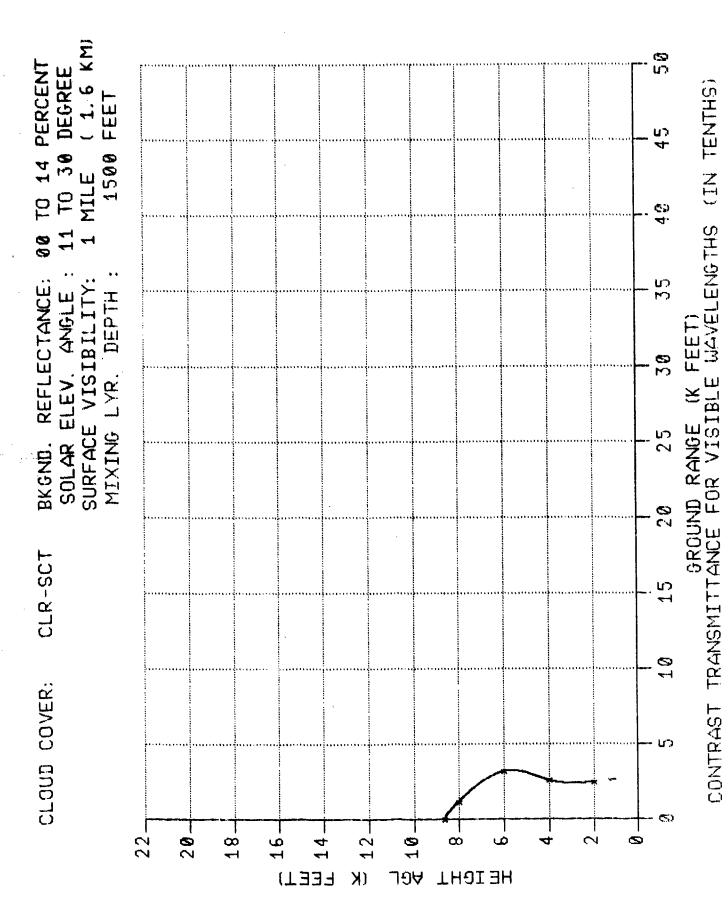
H-10



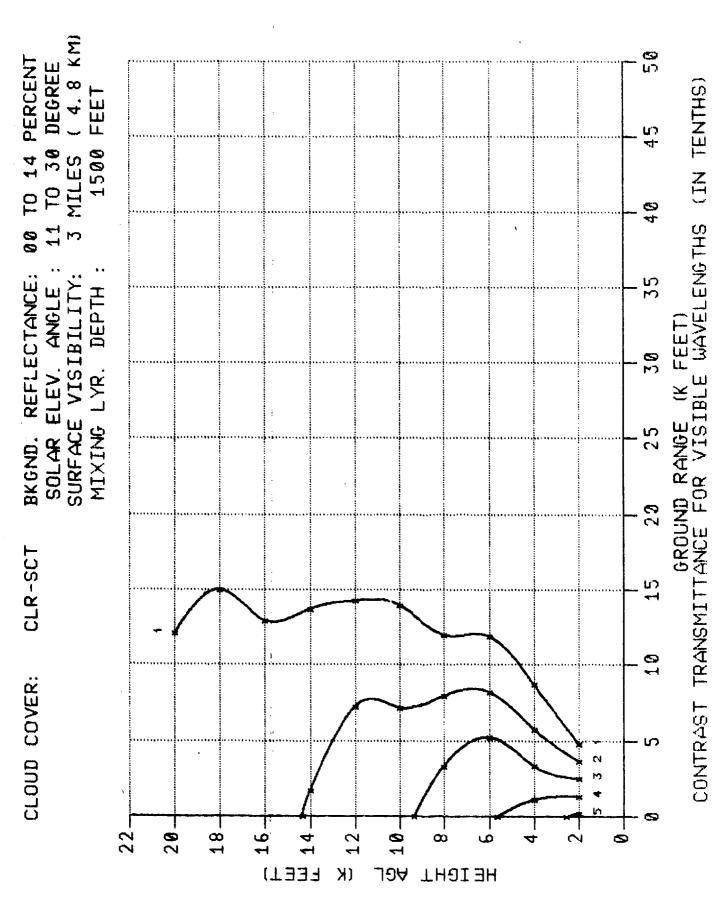
H-102

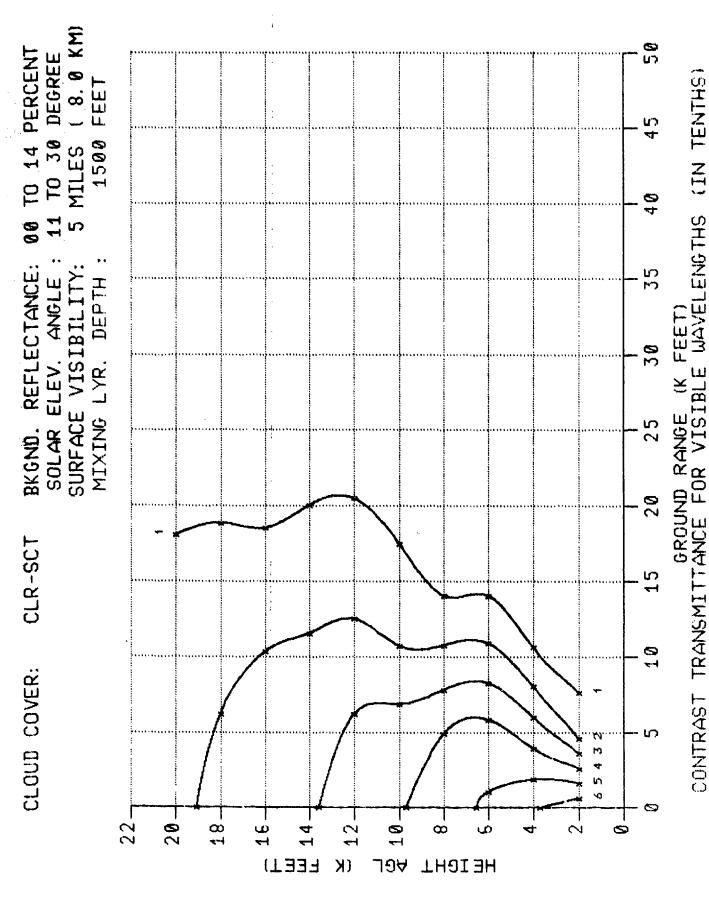


H-103

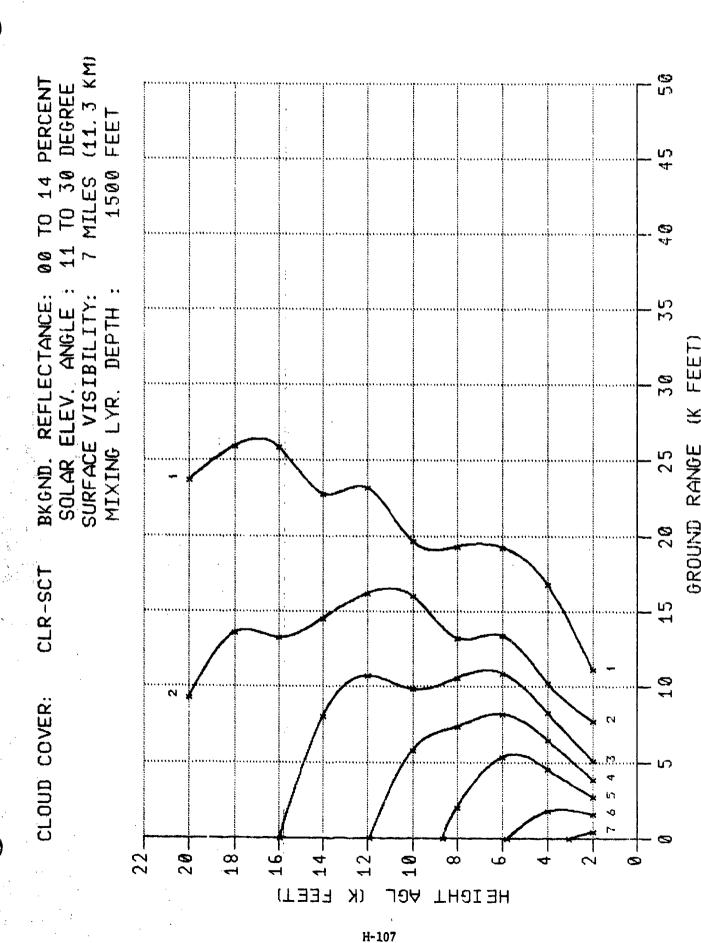


H-104

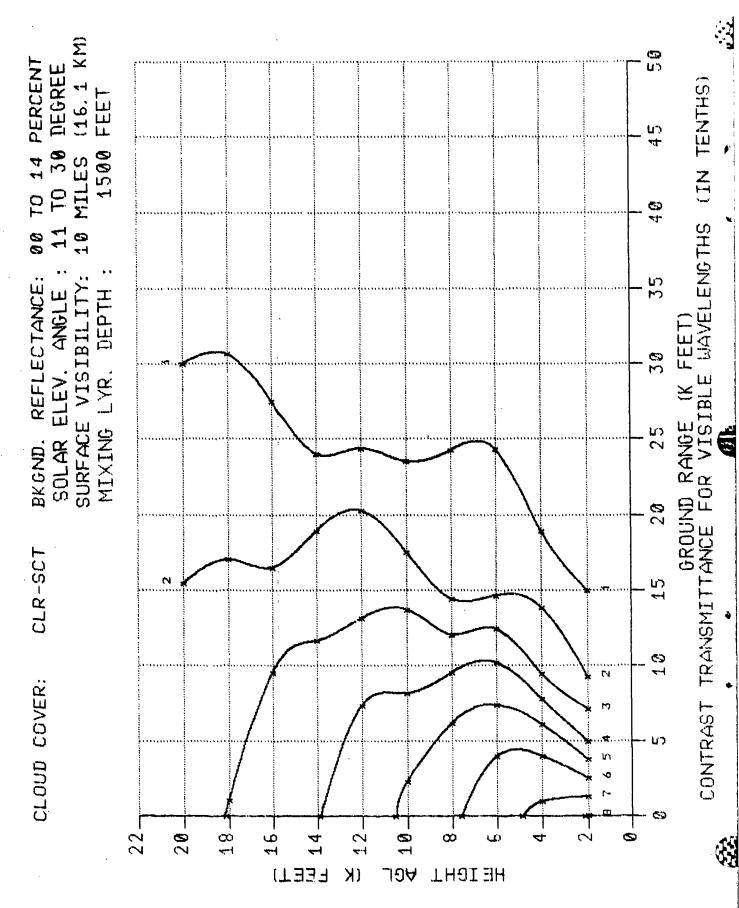




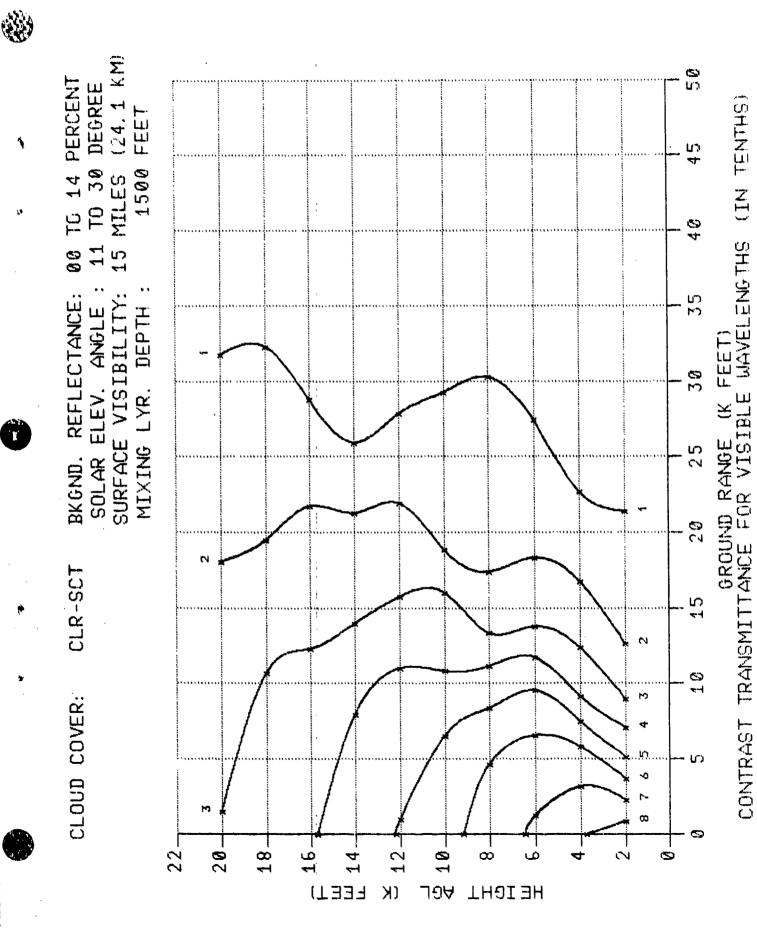
H-106



GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

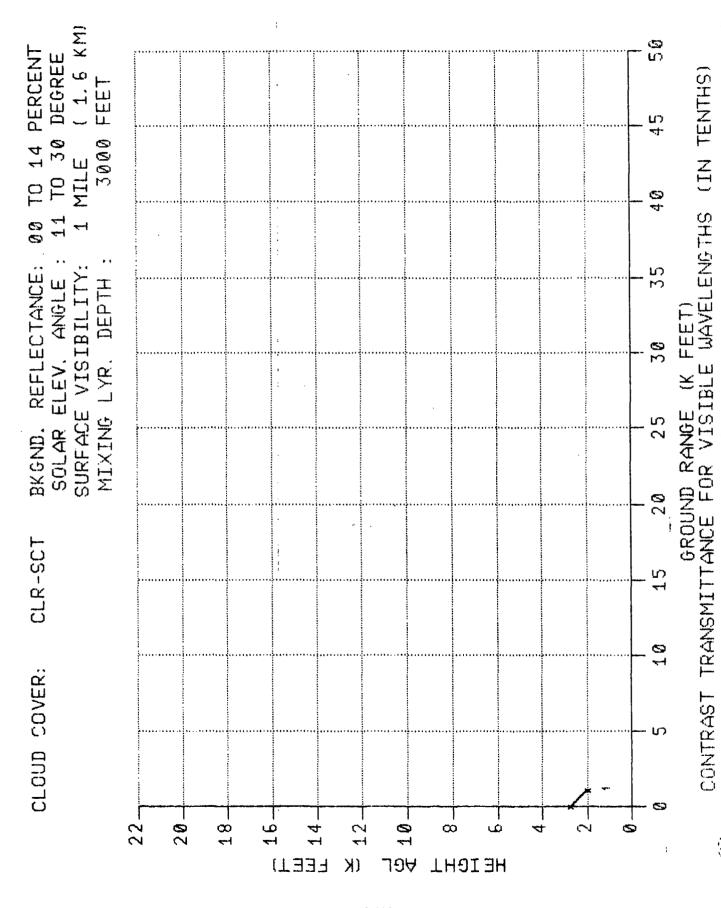


H-108



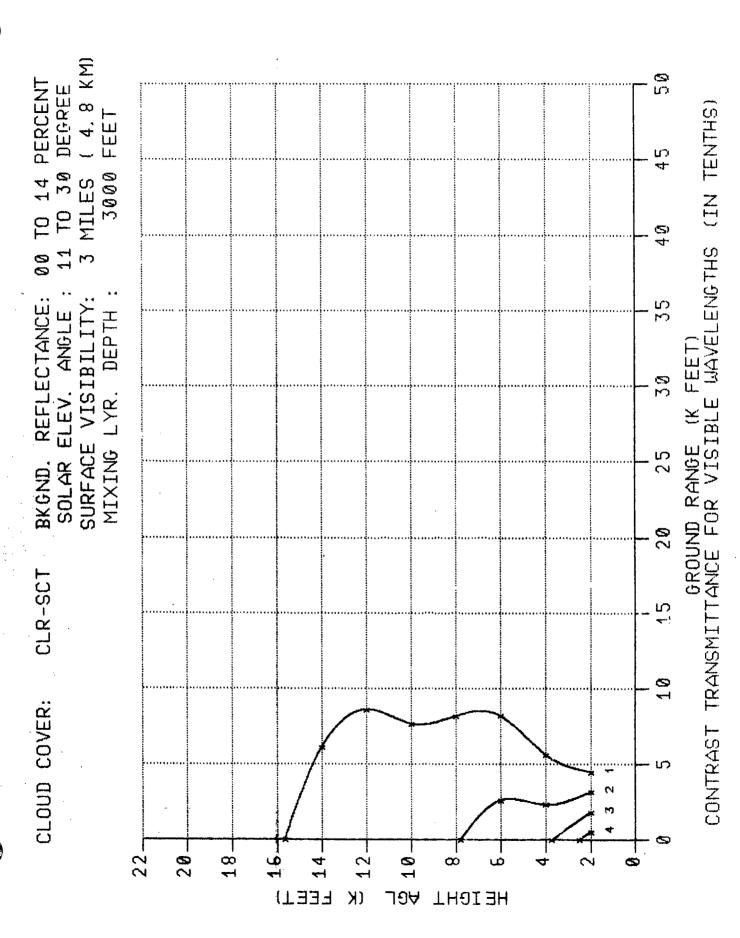
大大地

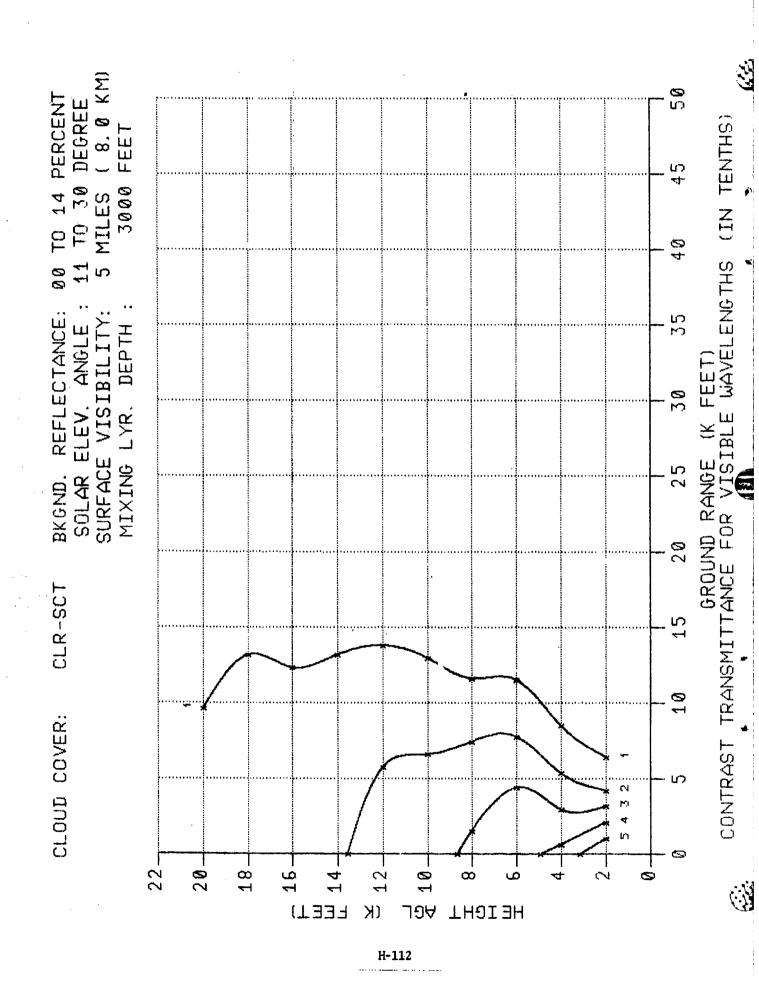
H-109

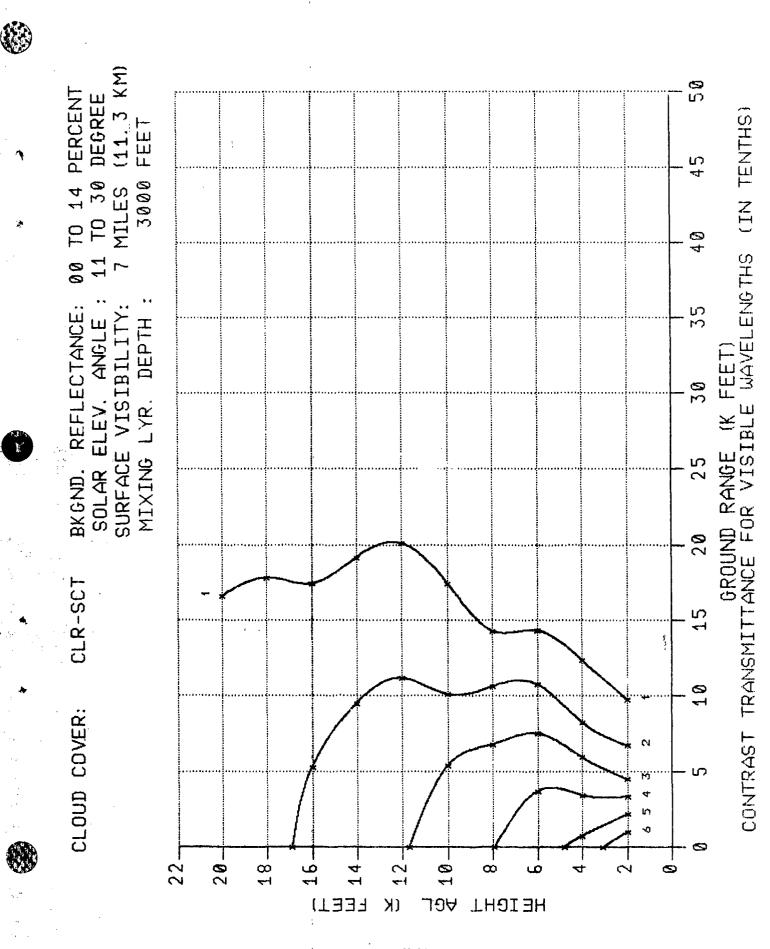


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H-110

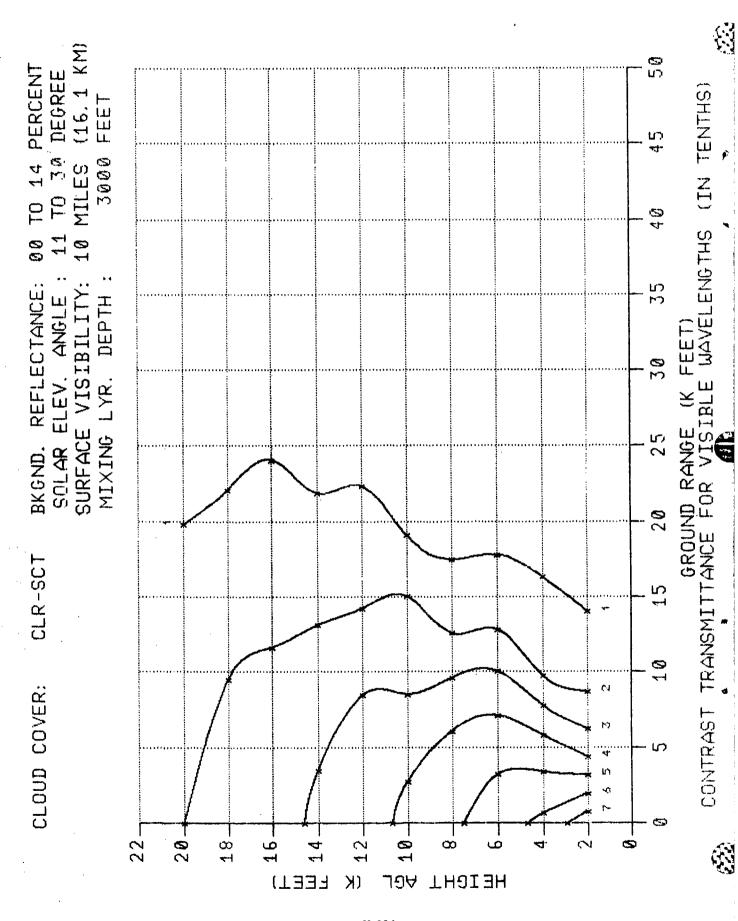




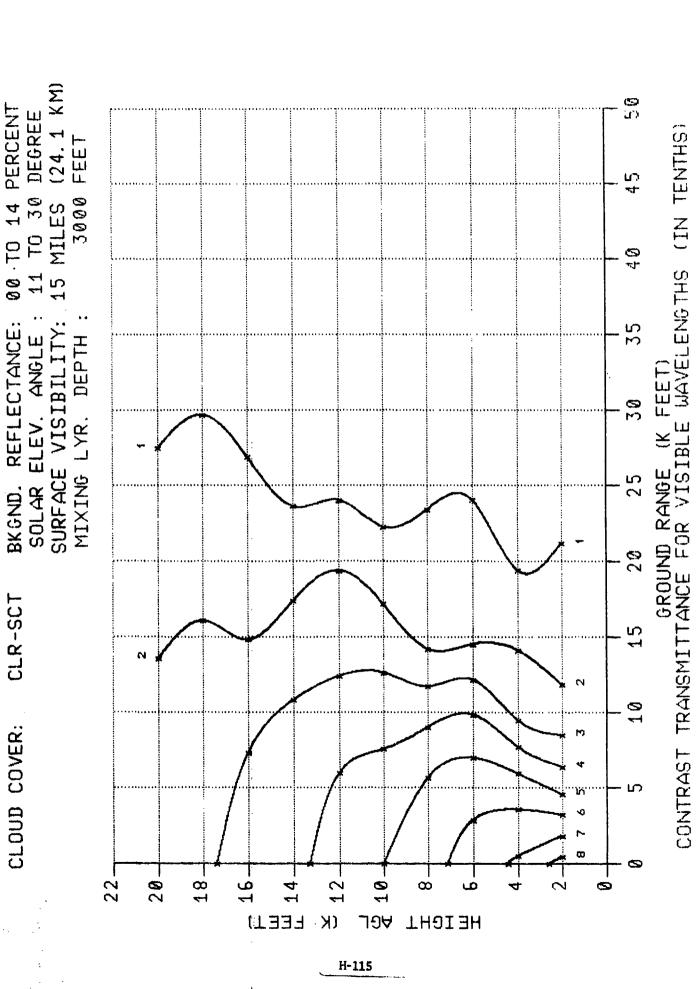


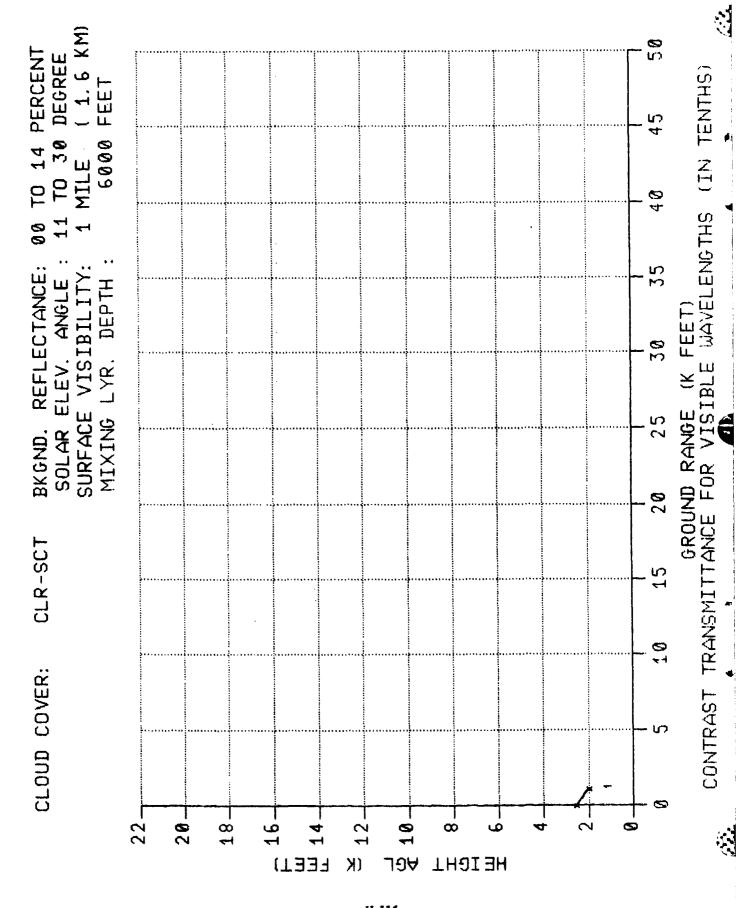
Mark Market St.

H-113

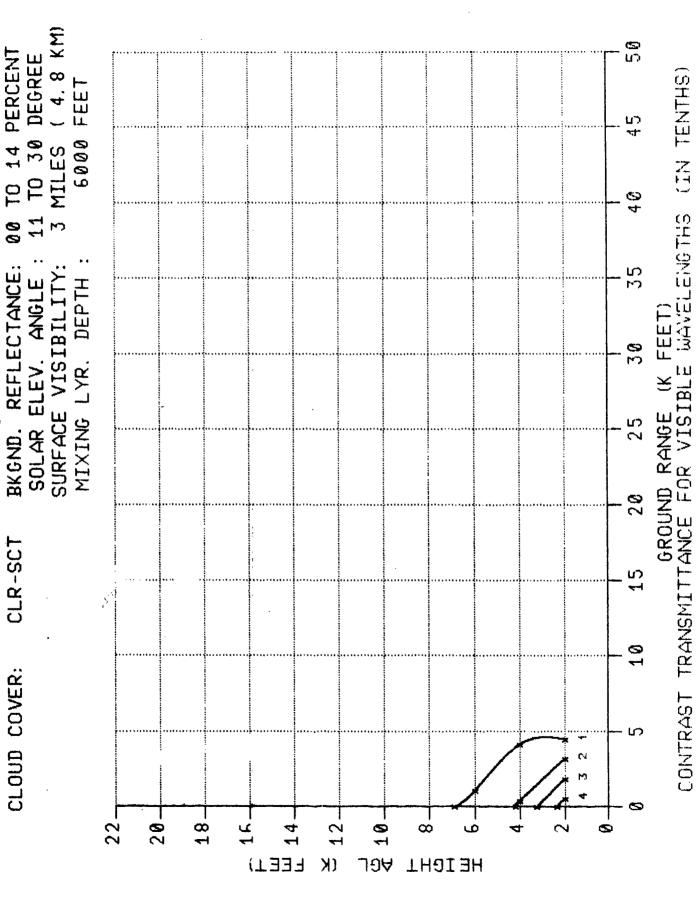


H-114



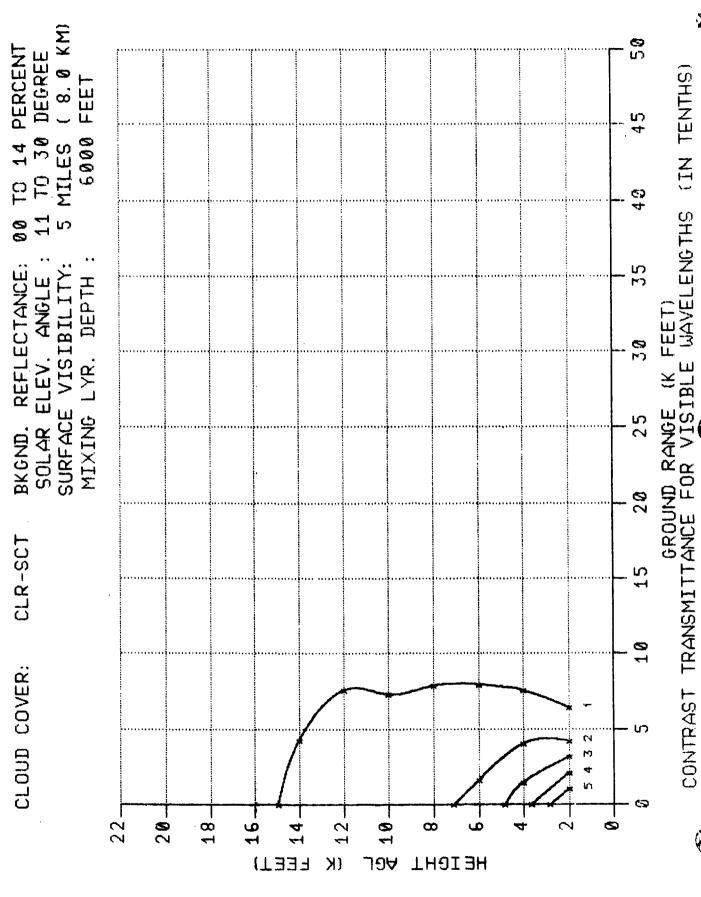


H-116

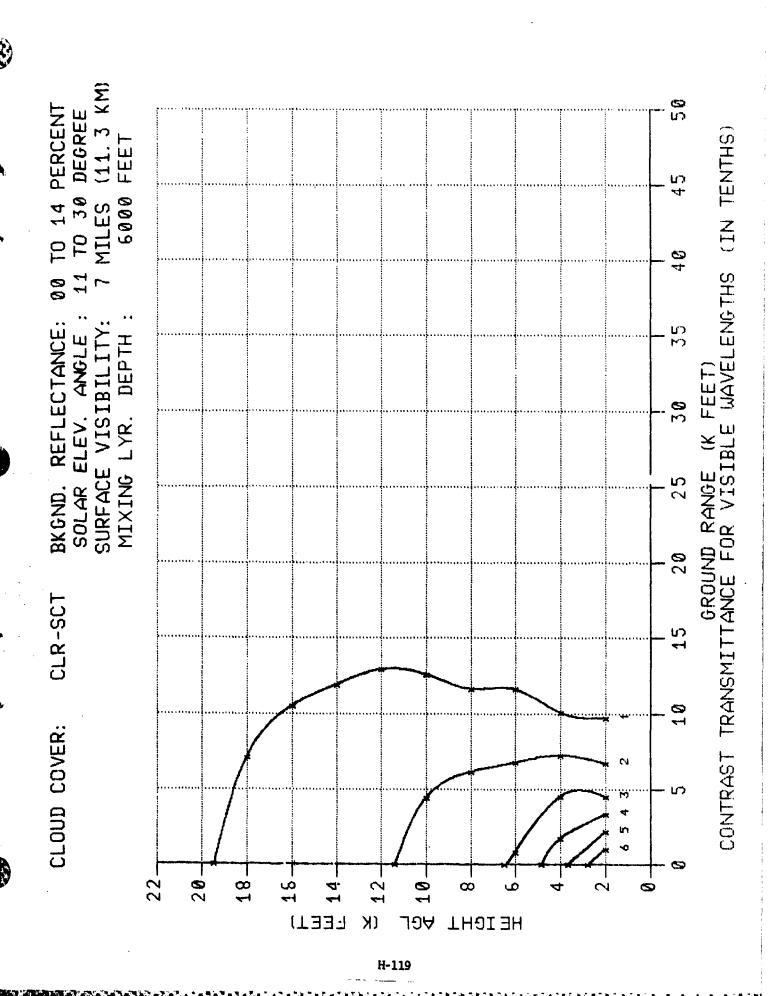


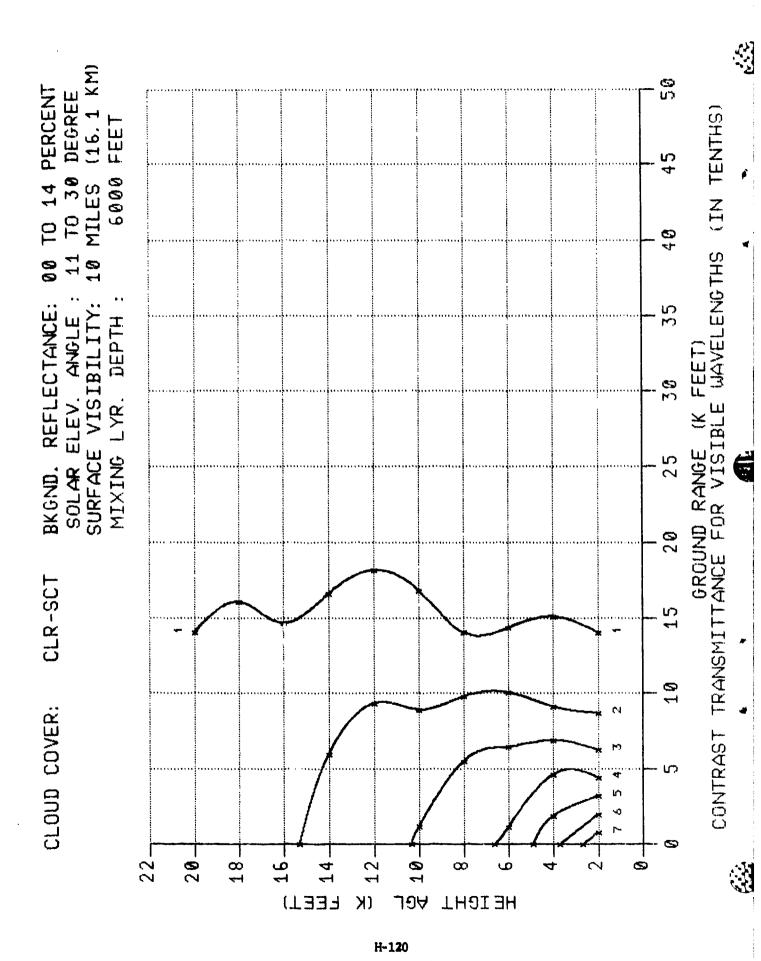
H-117

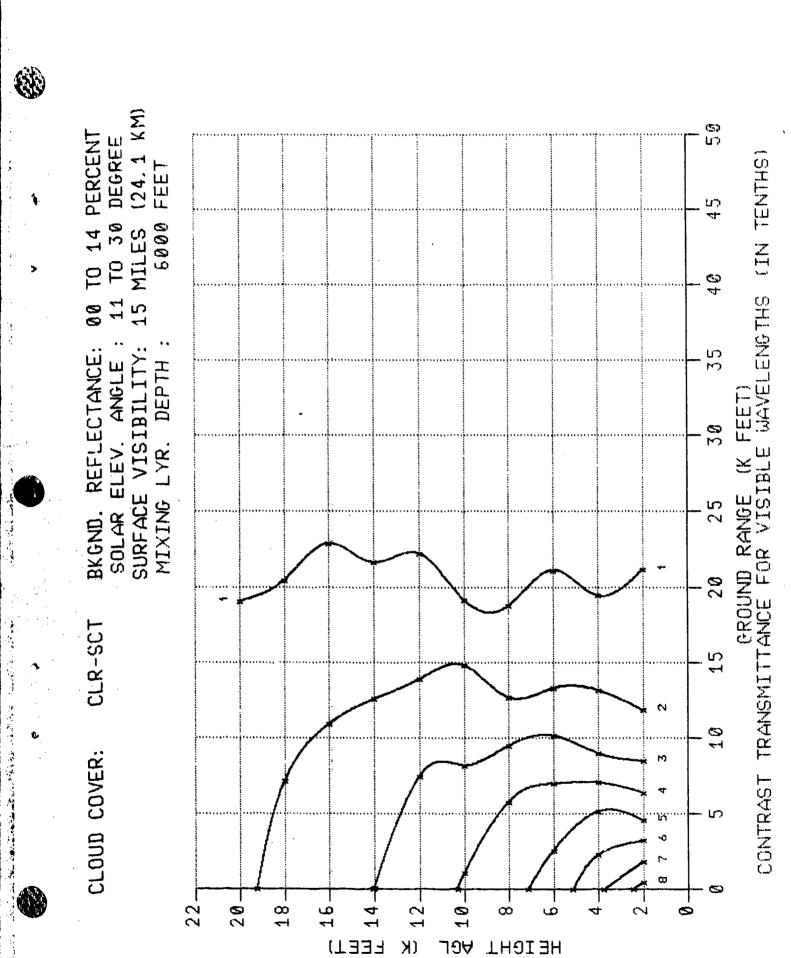
日本自己所以情報的五人名為人 下安心下一日



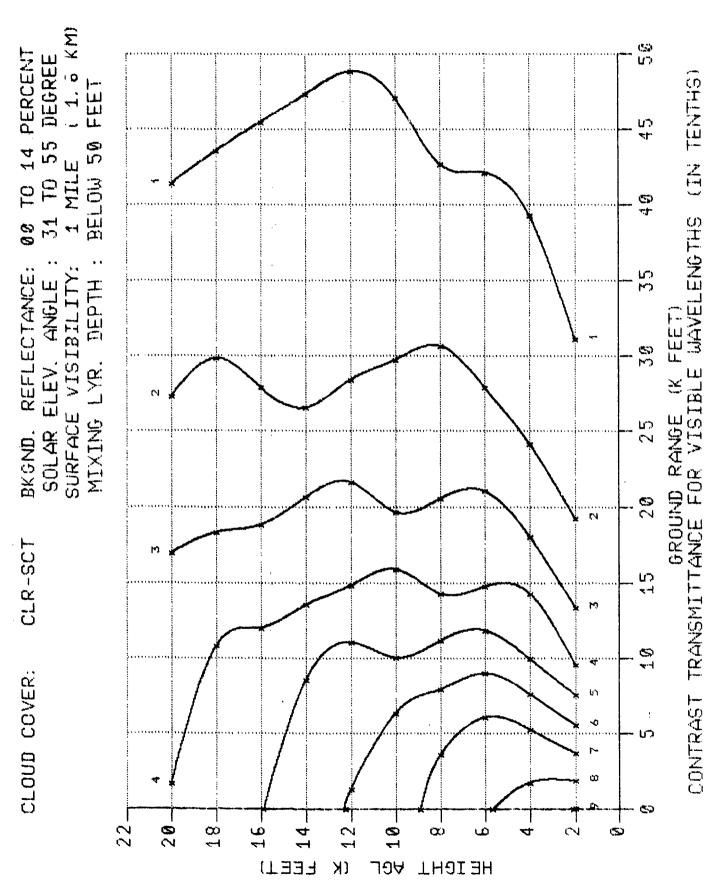
H-118





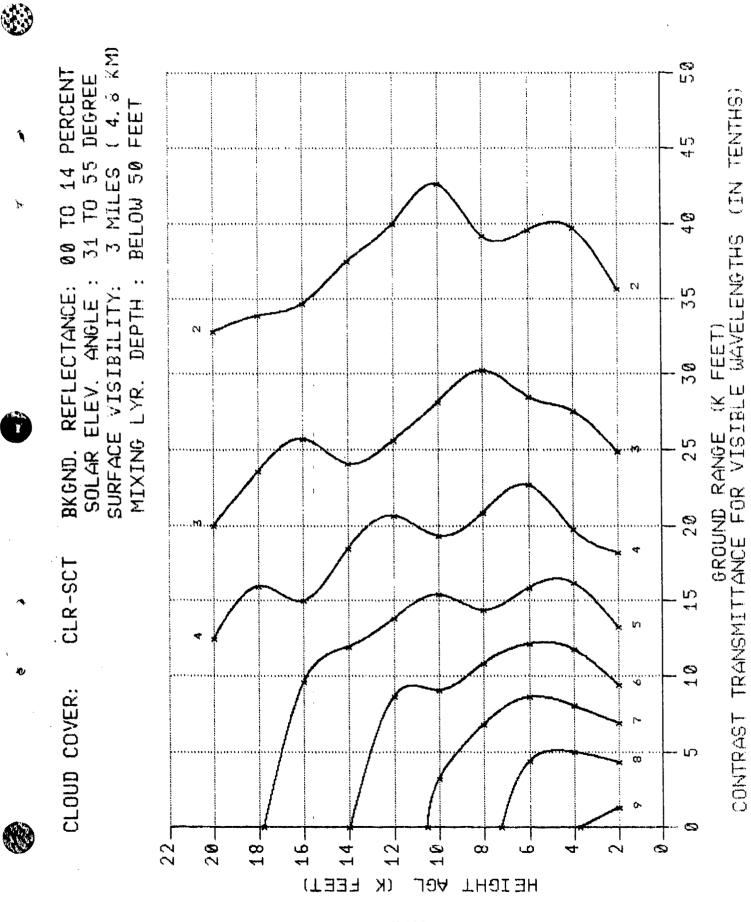


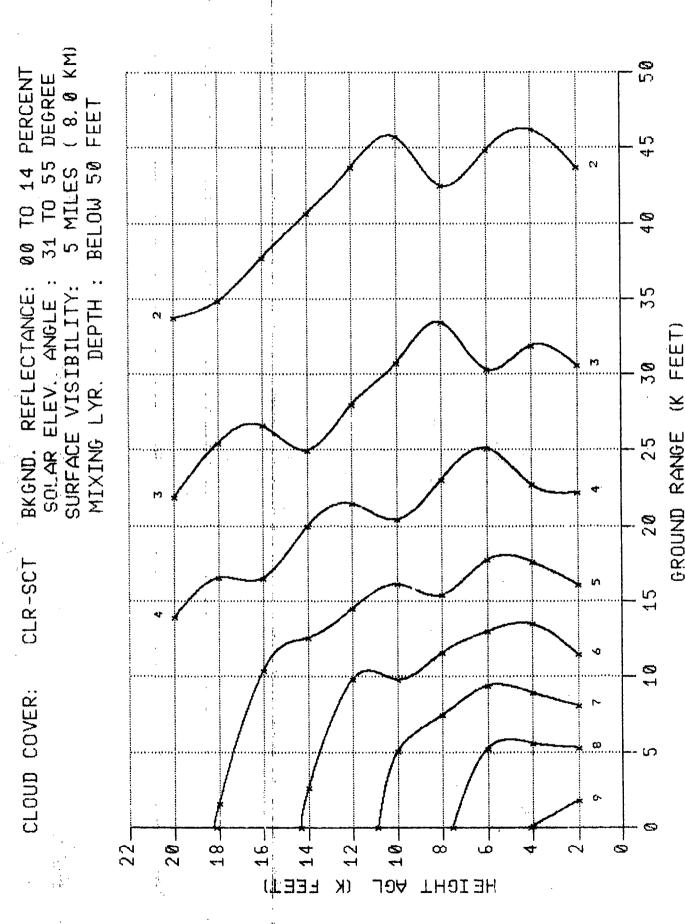
H-121



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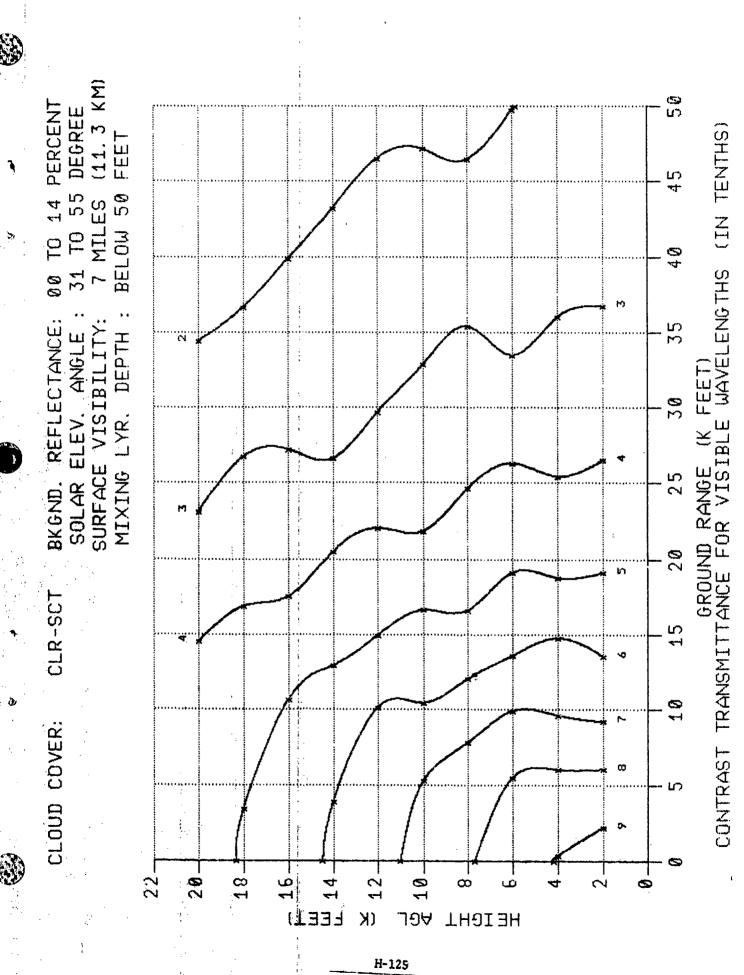
H-122

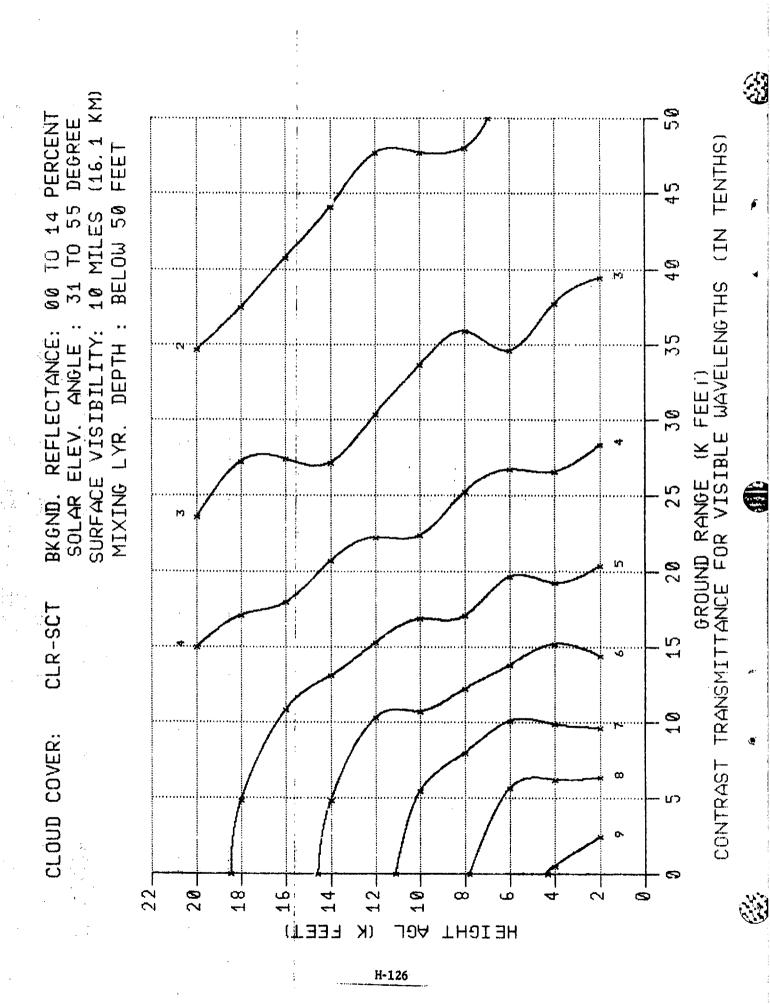


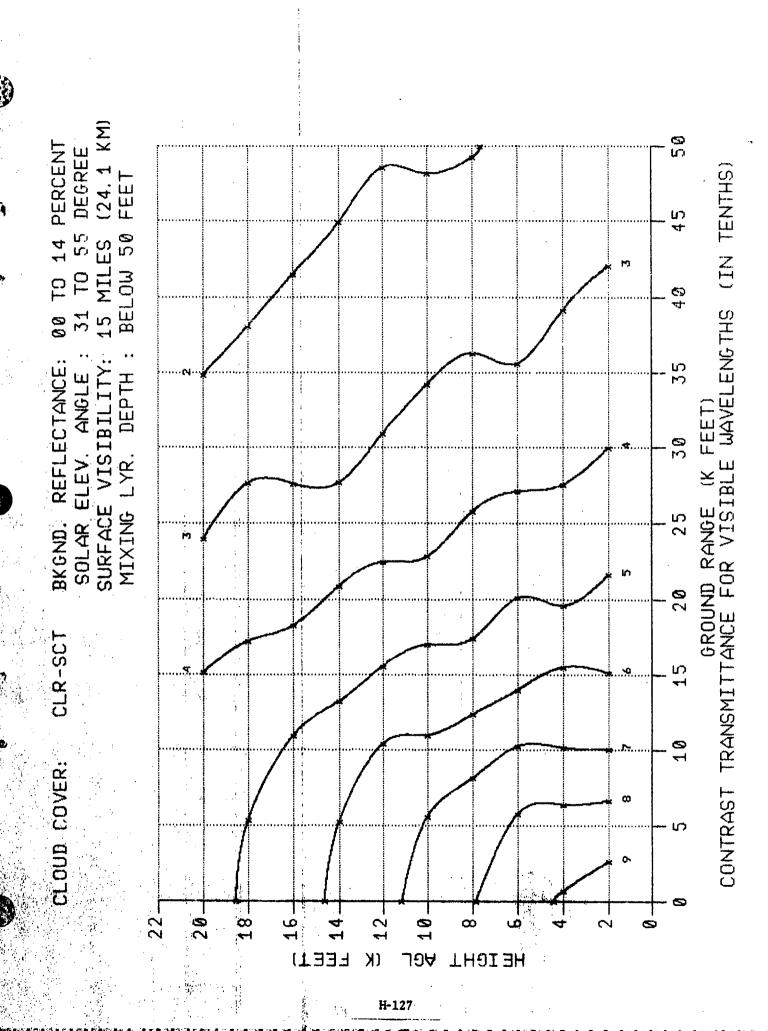


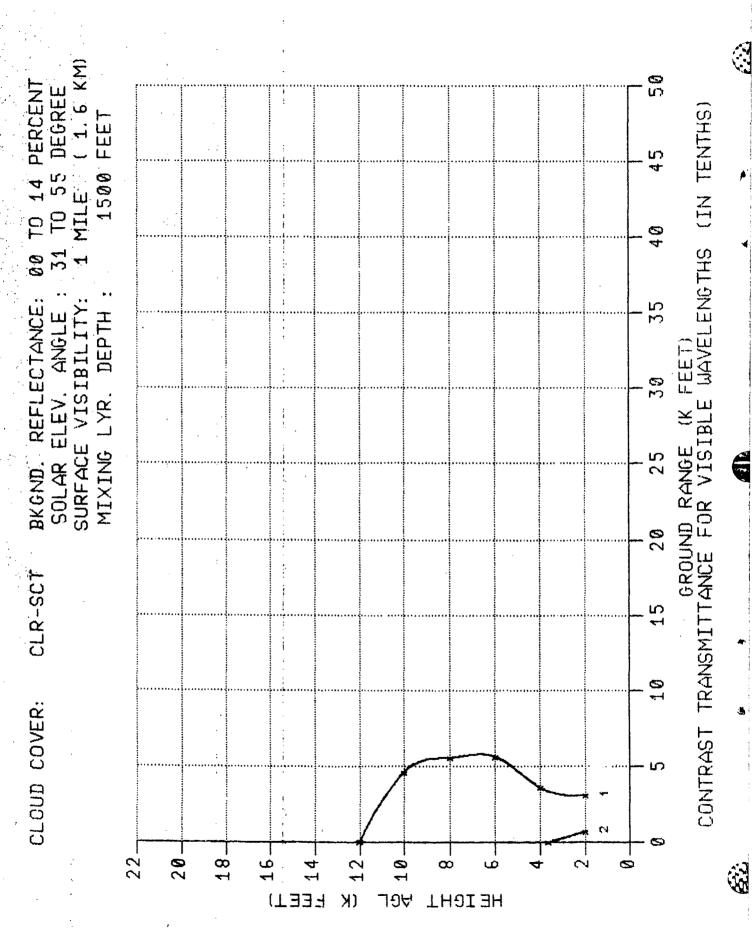
H-124

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)



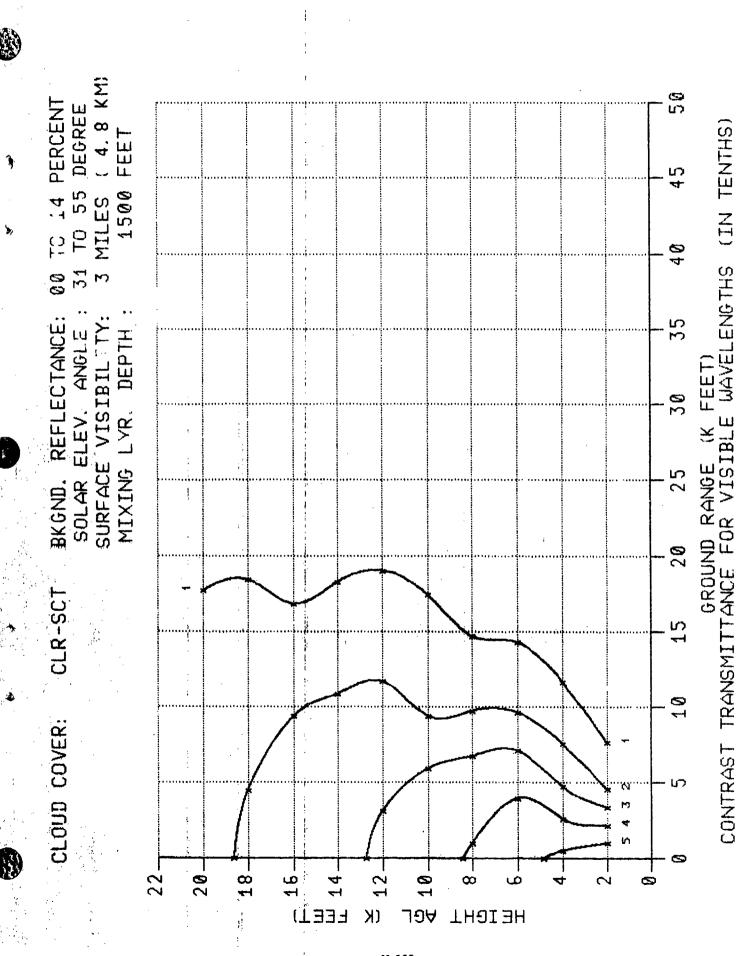


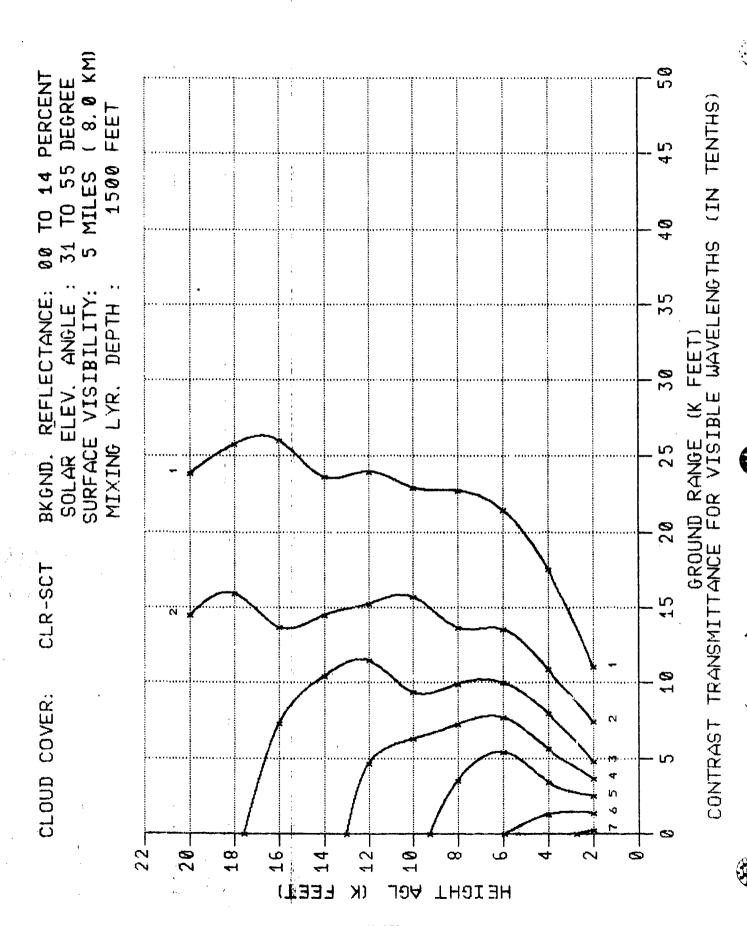




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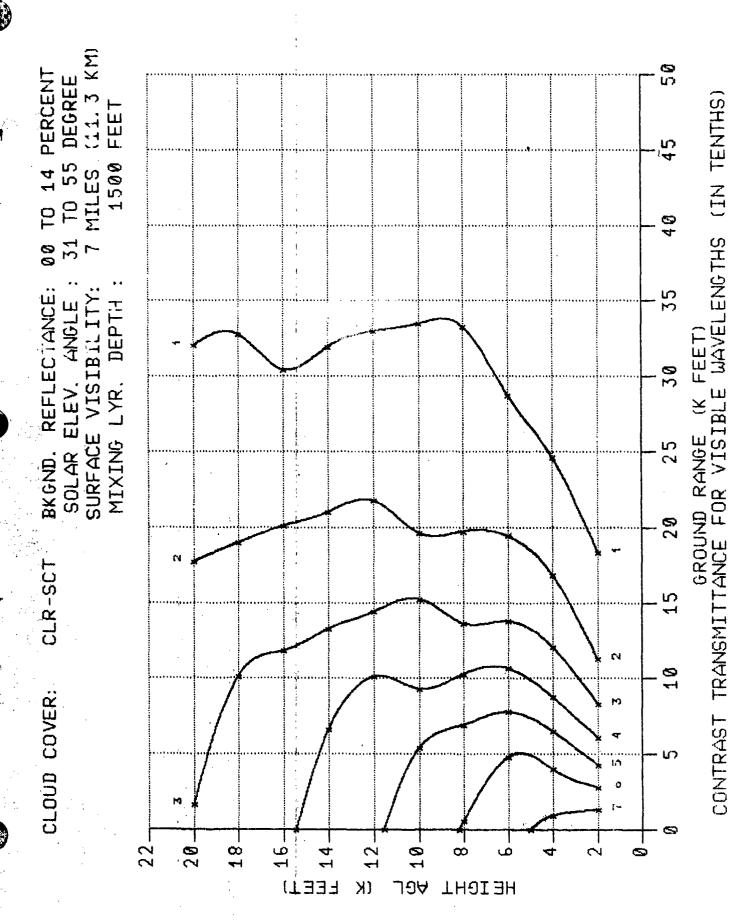
H-128





H-130

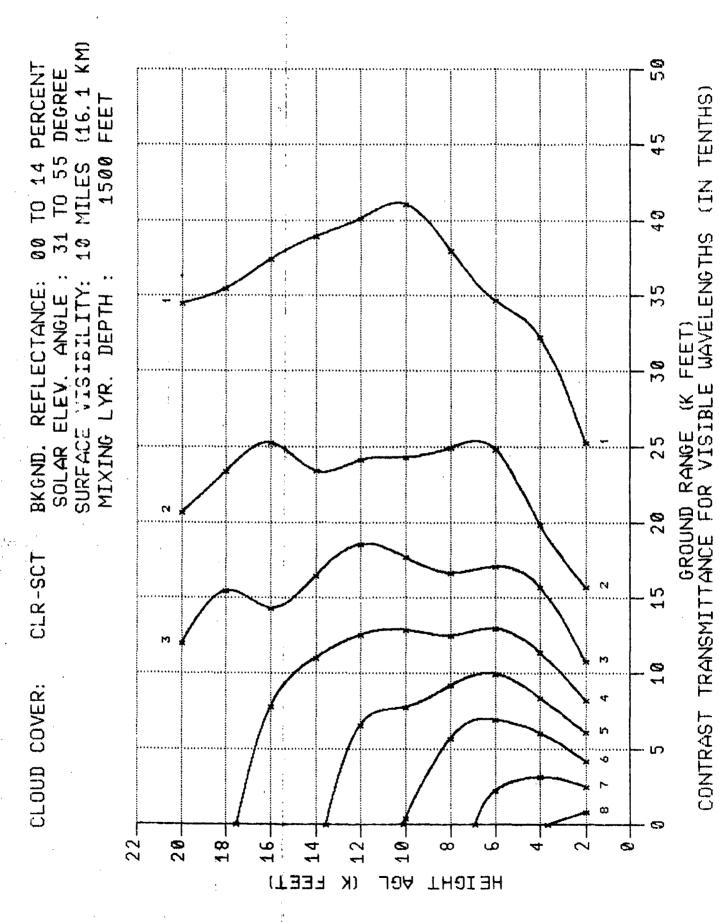
THE RESERVE THE PARTY OF THE PA



我就是我的人的人 一年一日的人的人 一起我们是我的人,我们可以是一个我们的我们

留然 治理者 等被污痕的

H-131



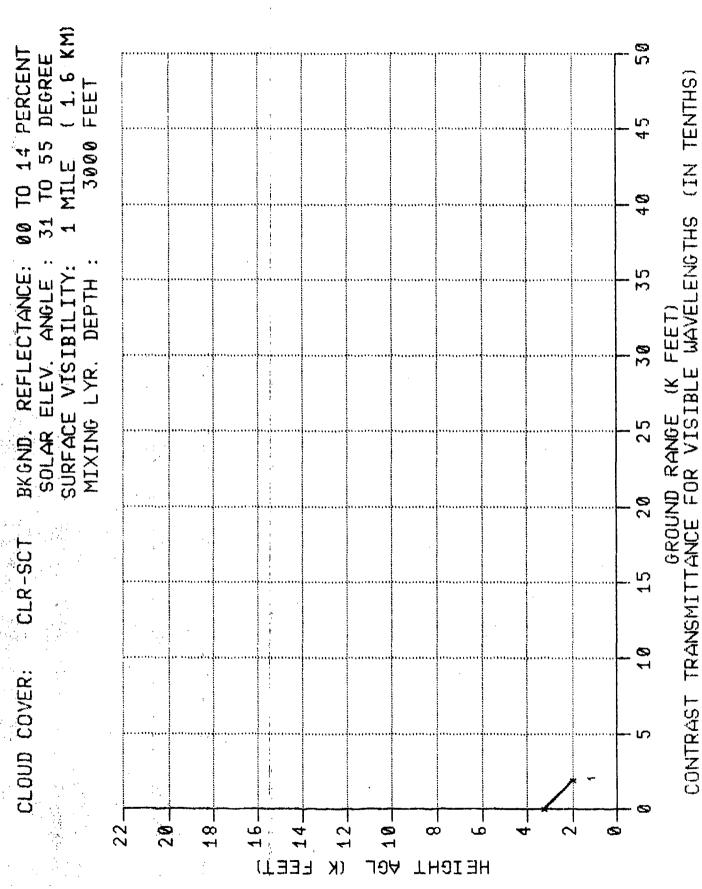
A Marie Contract

The state of the s

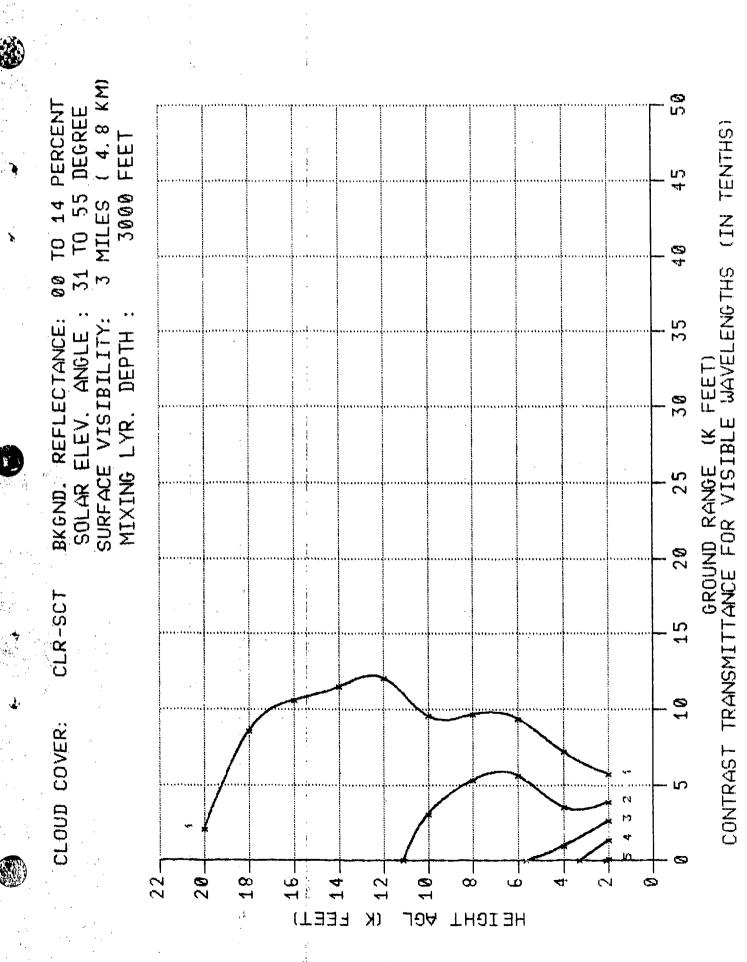
一日の教育などをはない

H-132

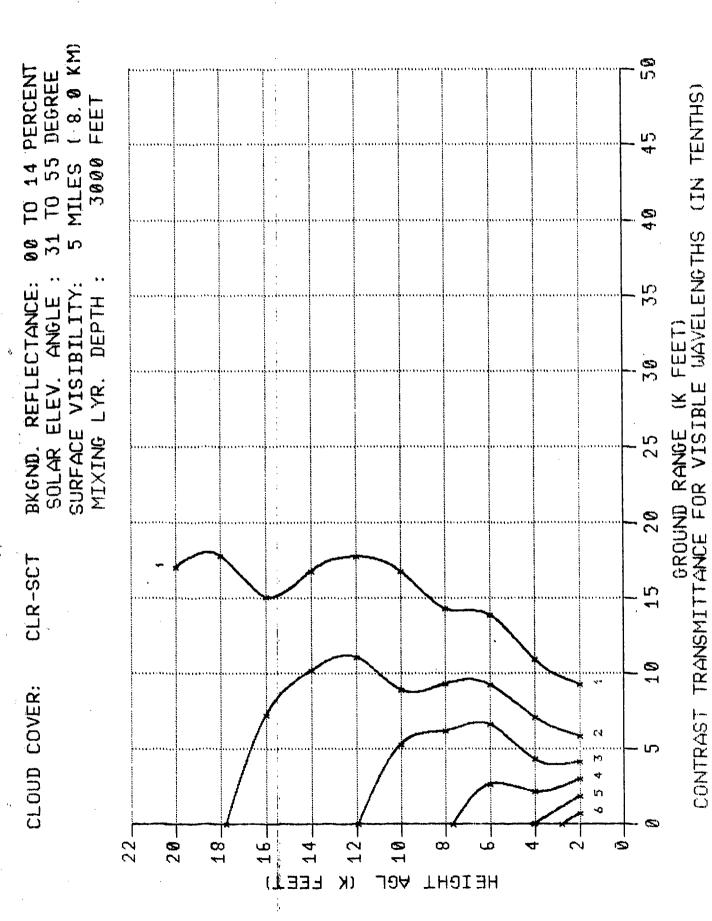
00 TO 14 PERCENT 31 TO 55 DEGREE 15 MILES (24, 1 KM) 1500 FEET ලා ග GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) 45 40 8 BKGND, REFLECTANCE: SOLAR ELEV. ANGLE: SURFACE VISIBILITY: 35 30 MIXING LYR. 25 20 CLR-SCT 15 10 CLOUD COVER: 12 10 4 20-18 16-တ 7 S ف (K חפר HE ICHT



H-134

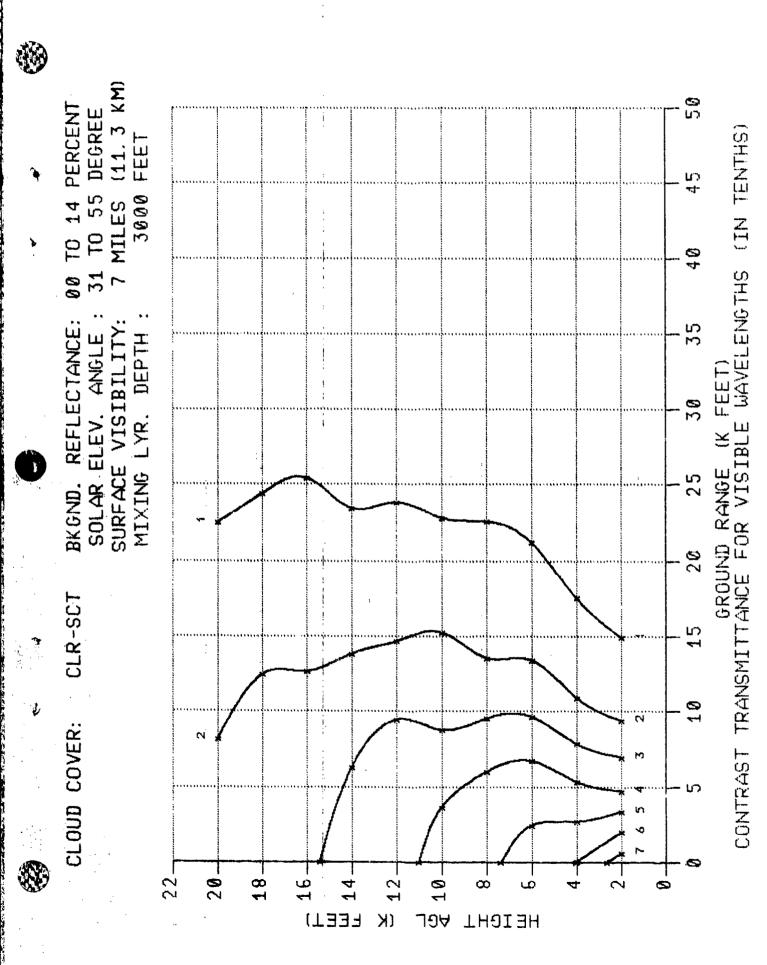


H-135

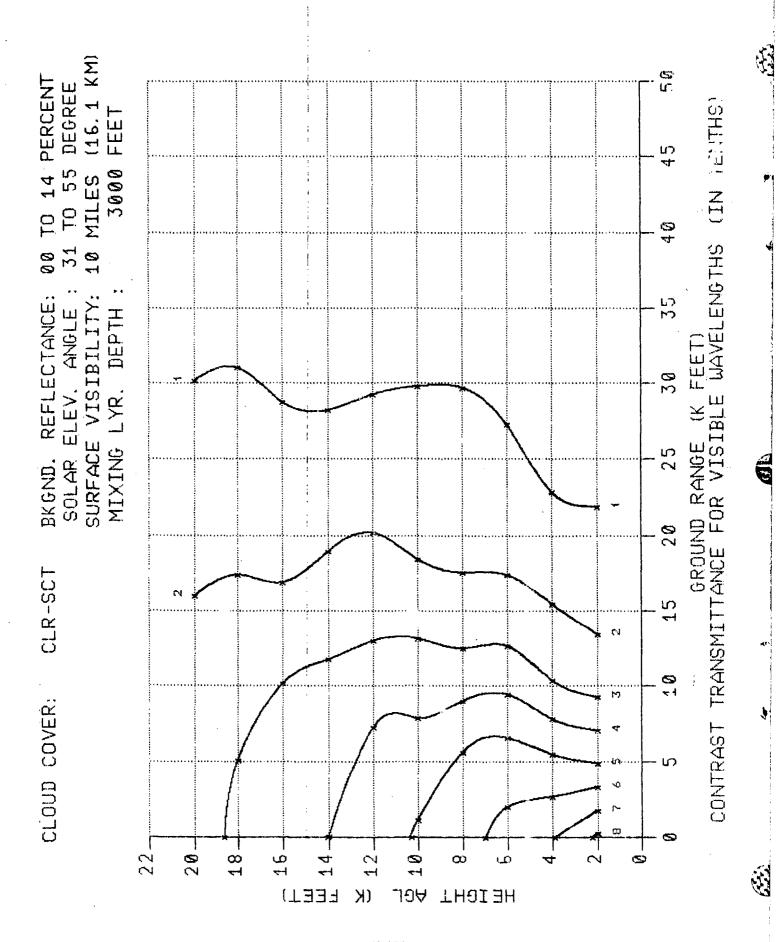


Kij

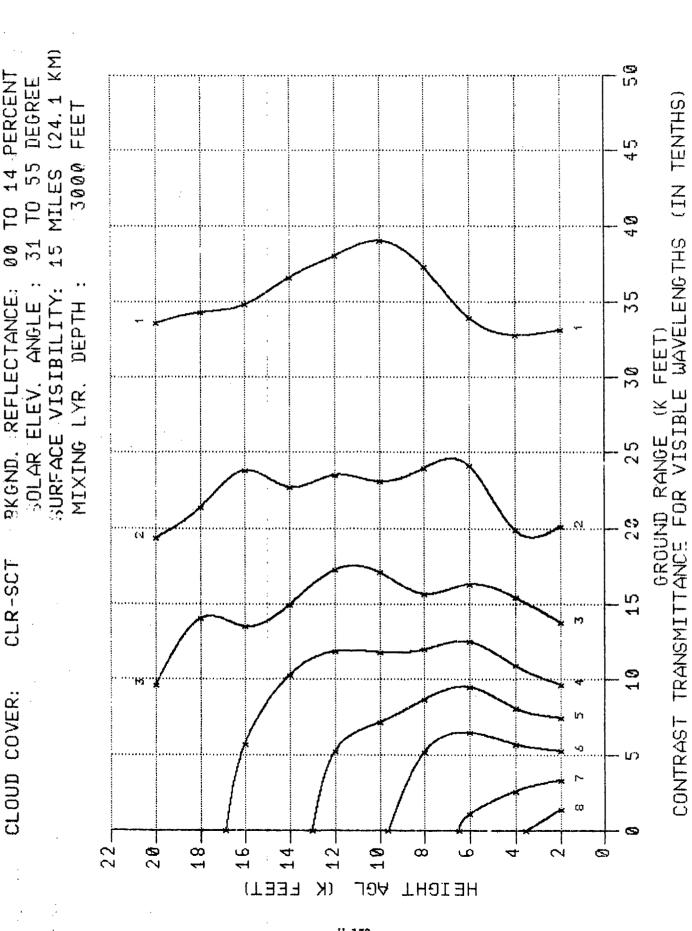
H-136



H-137



H-138

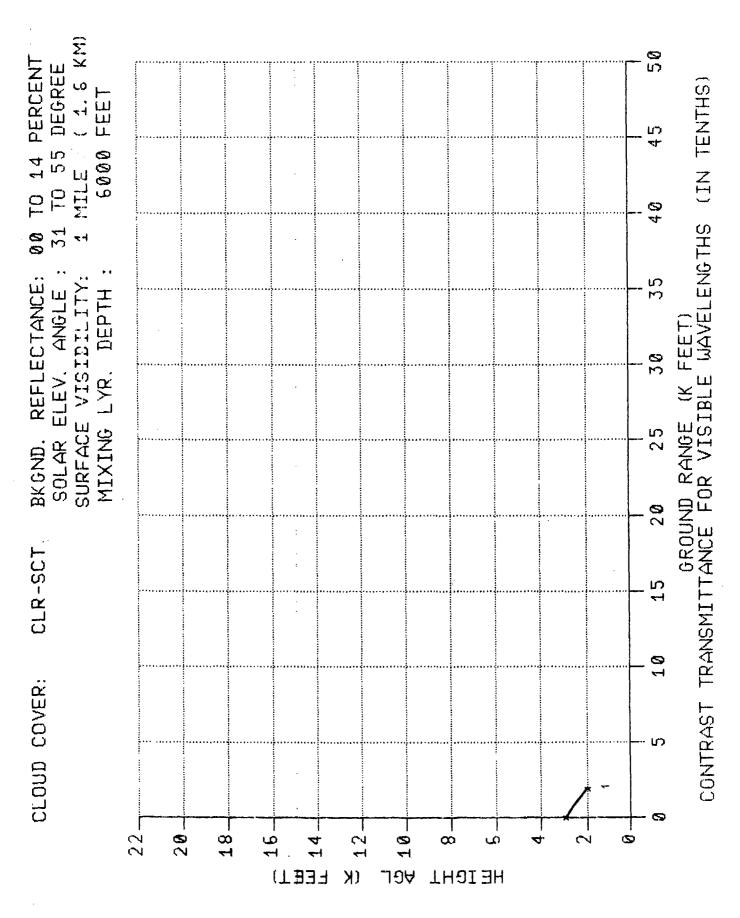


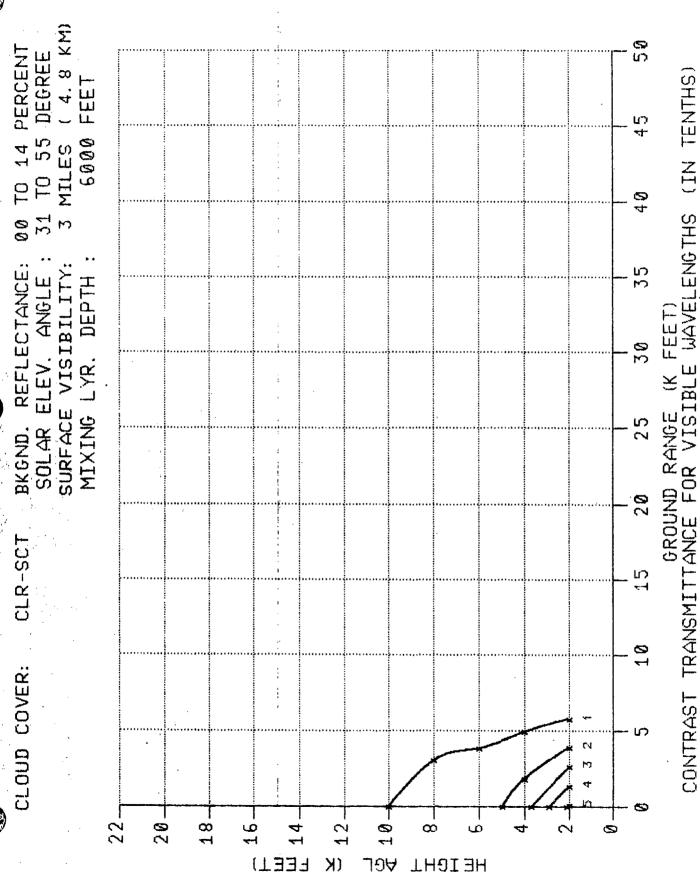
TO 14 PERCENT

BKGND, REFLECTANCE:

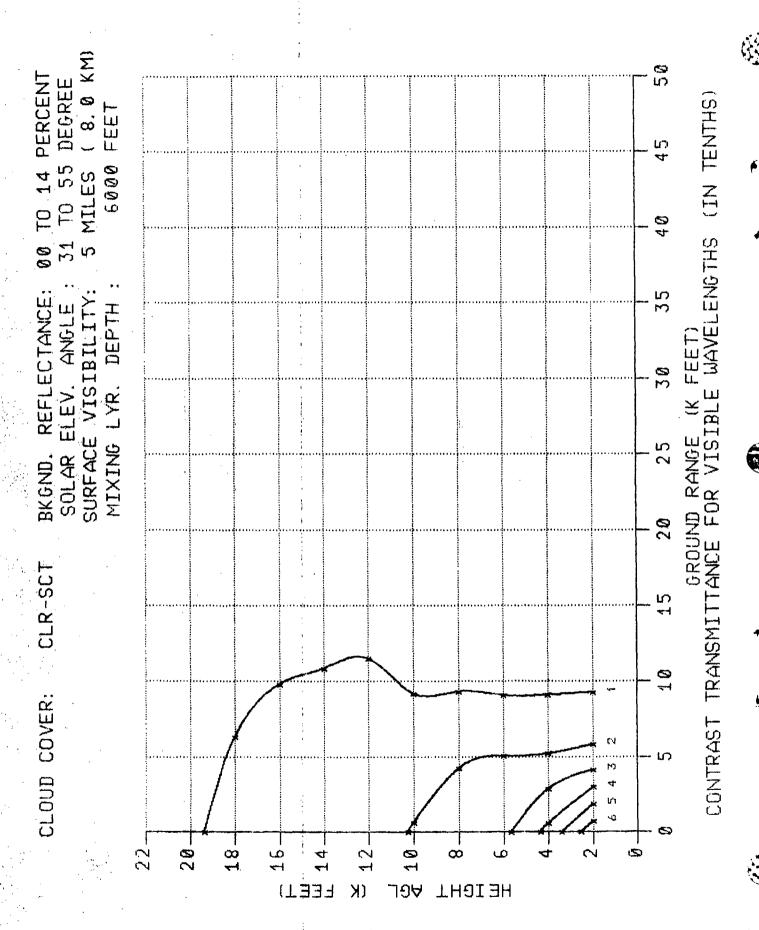
CLOUD COVER:

H-139

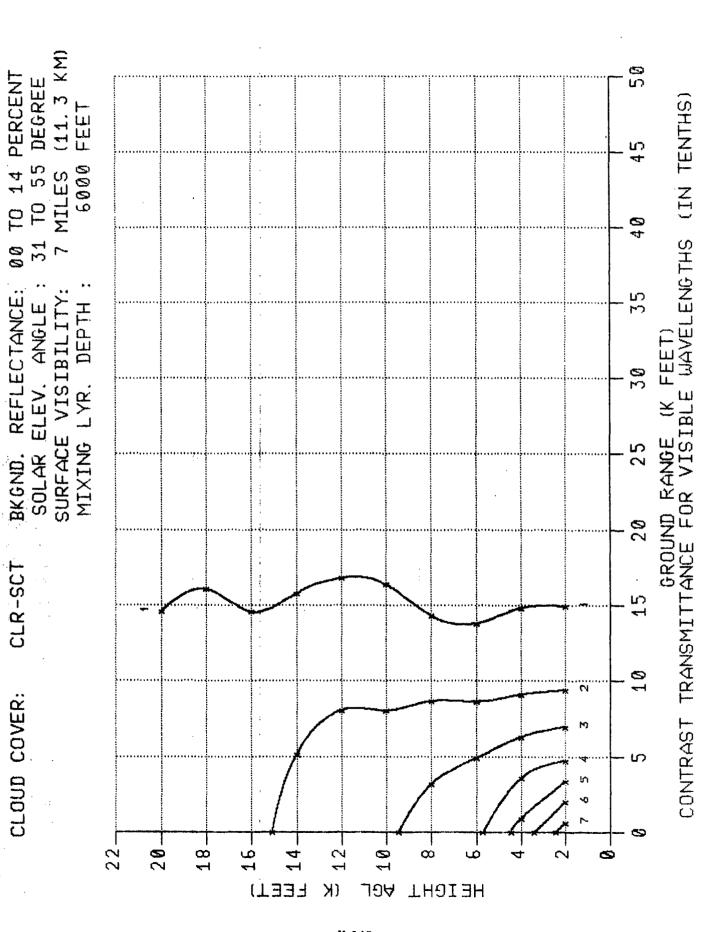




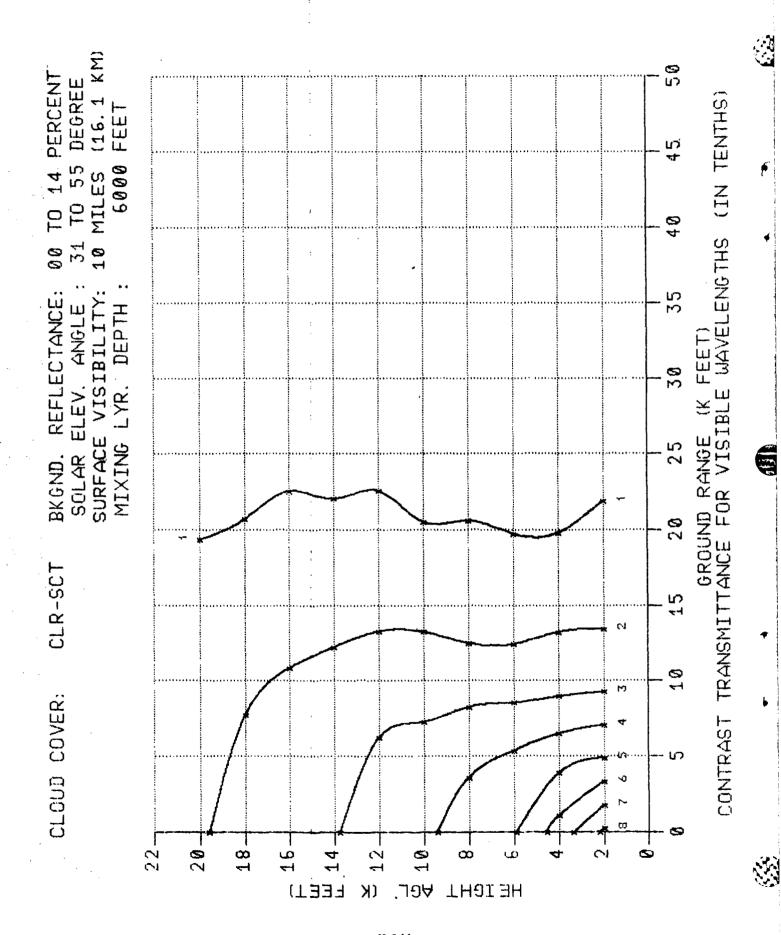
H-141



H-142



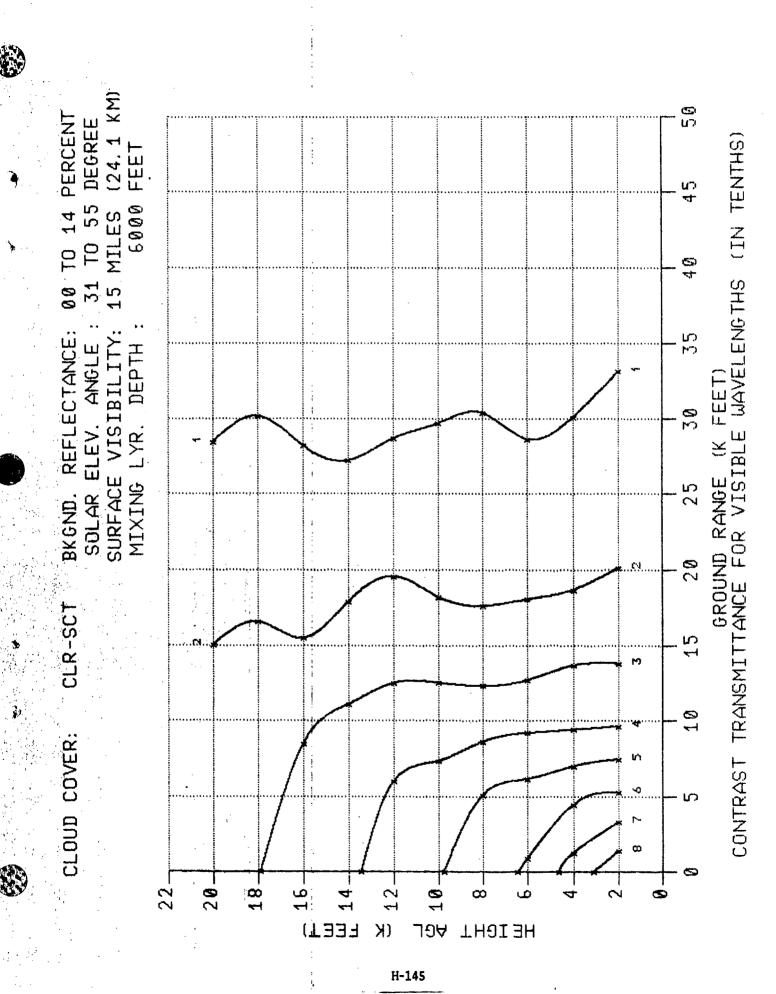
H-143

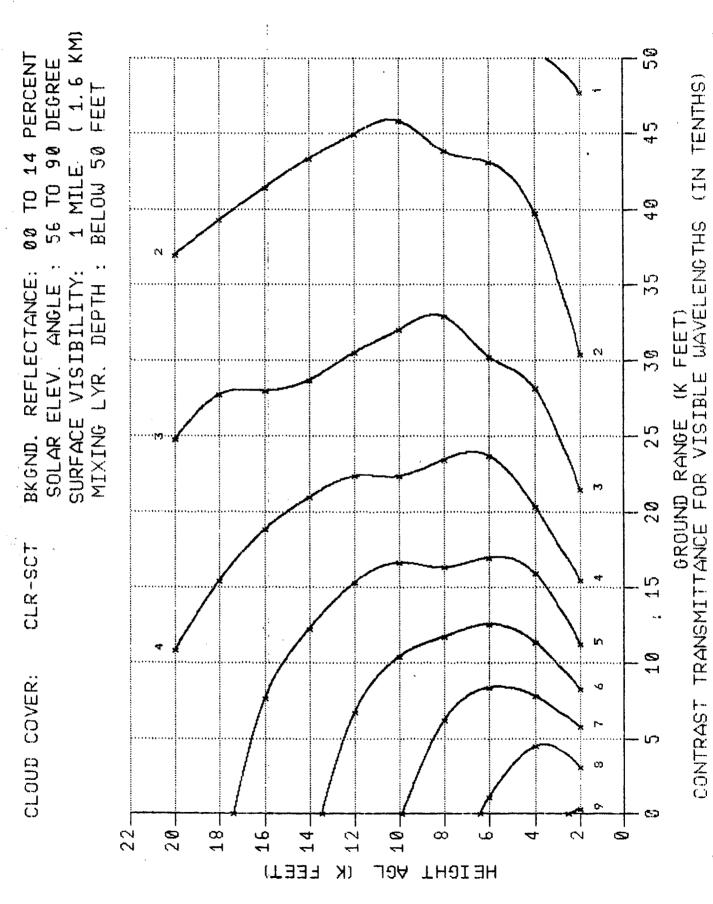


100

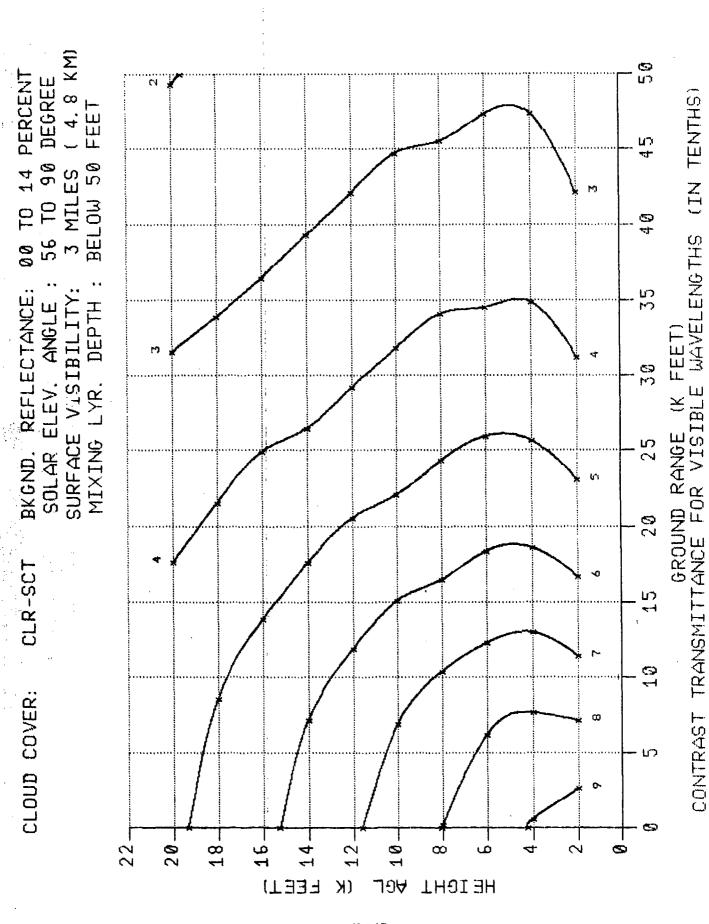
The state of the s

H-144

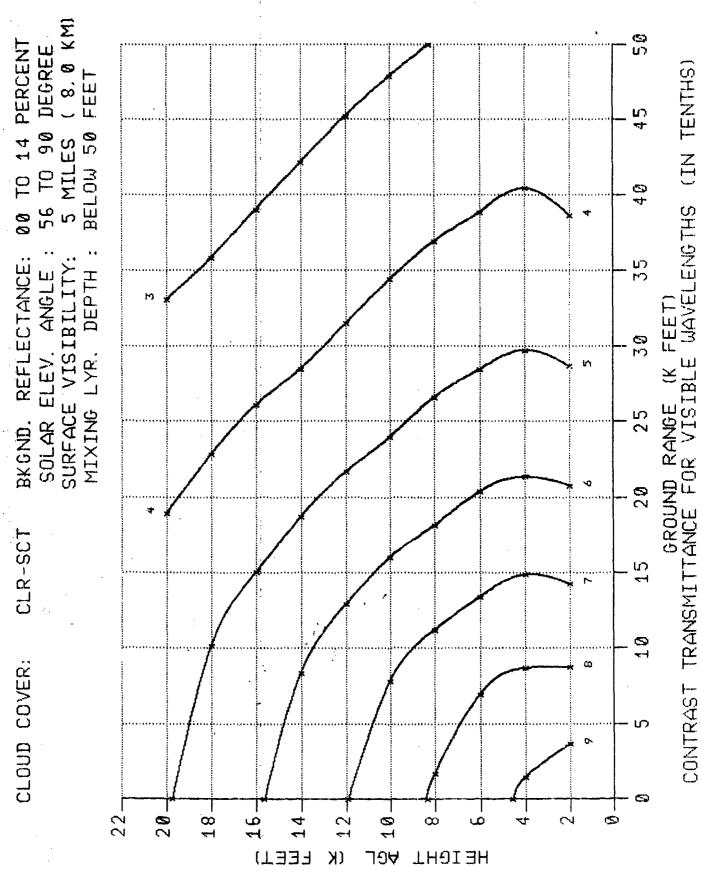




H-146

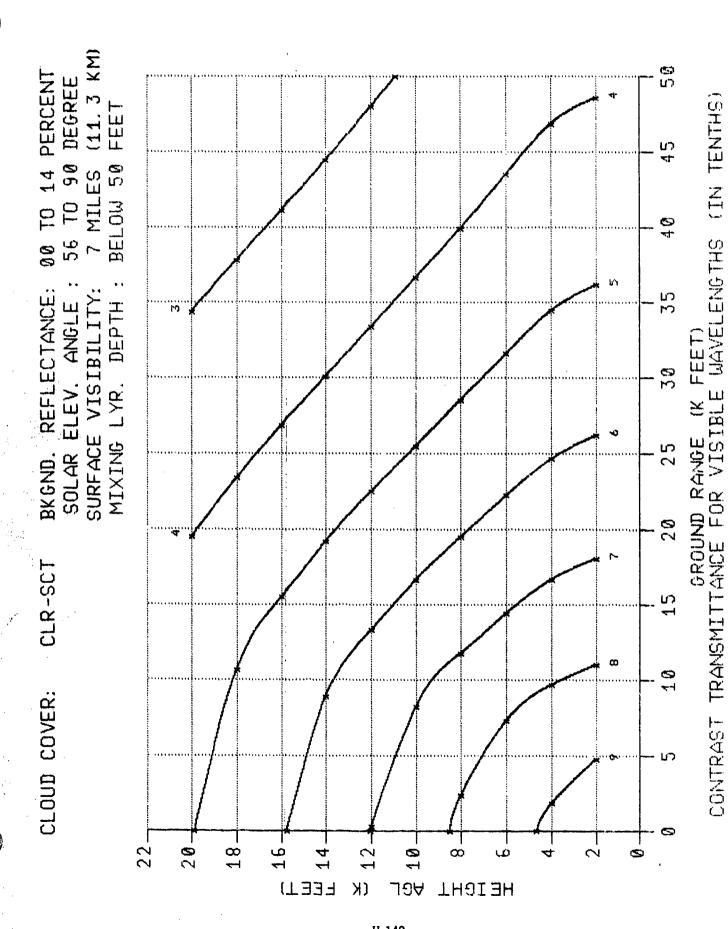


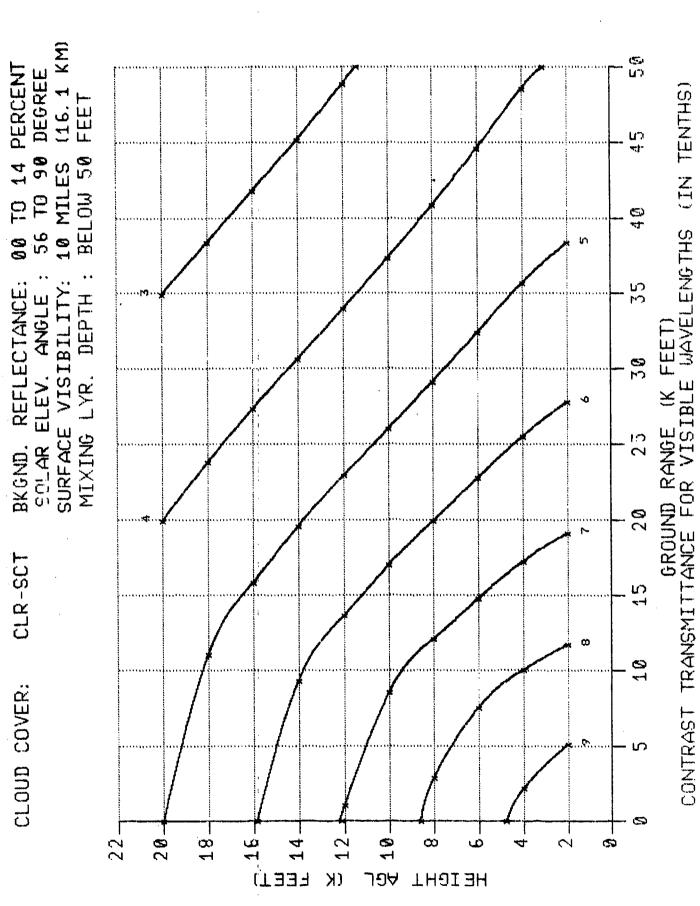
H-147



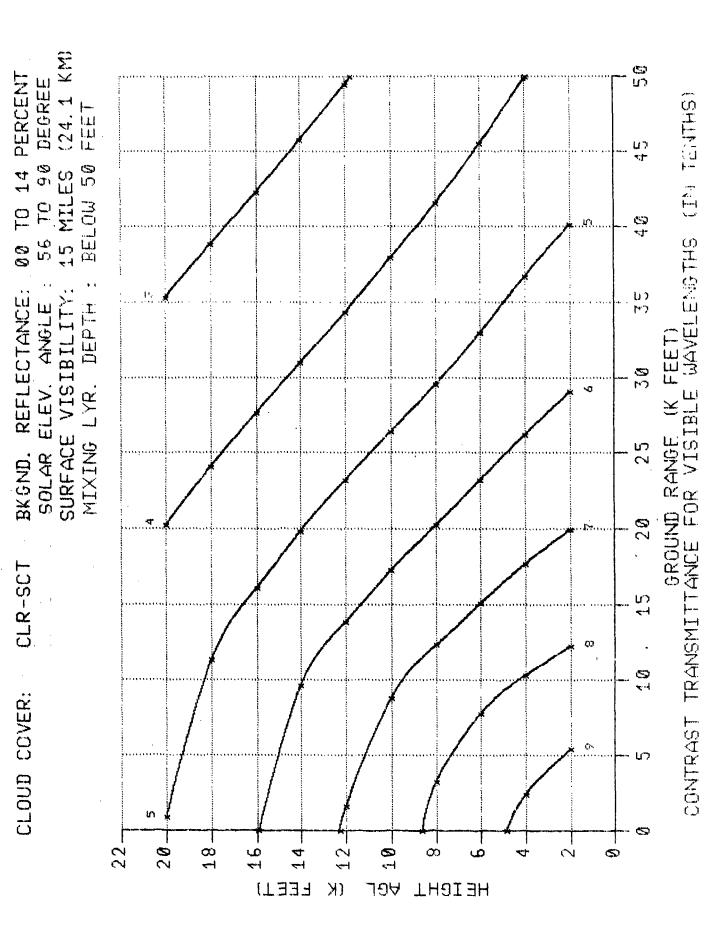
が変えない。

H-148

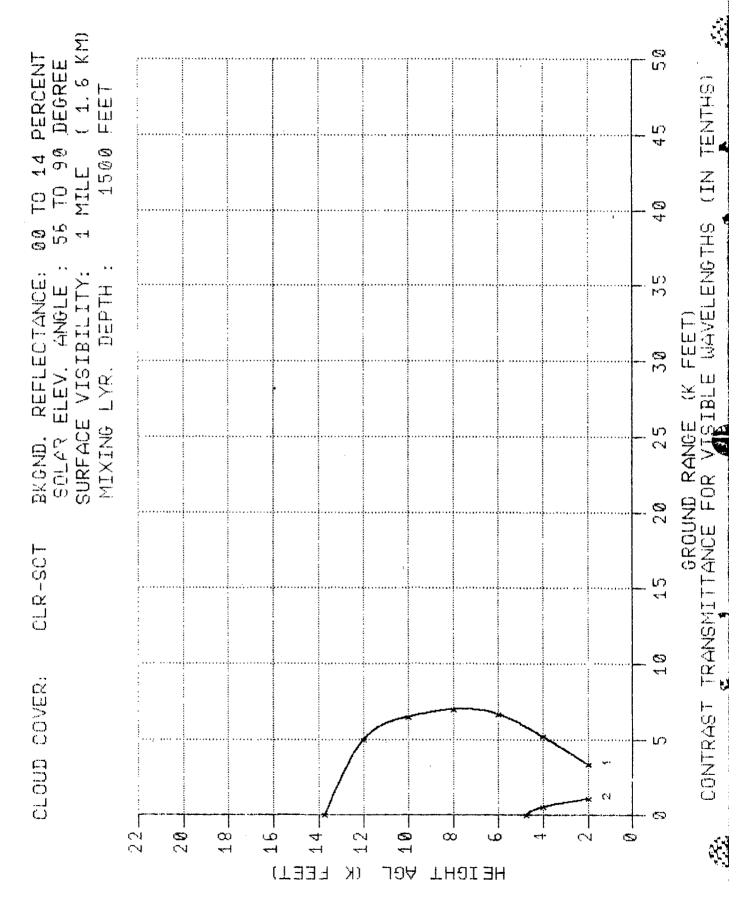




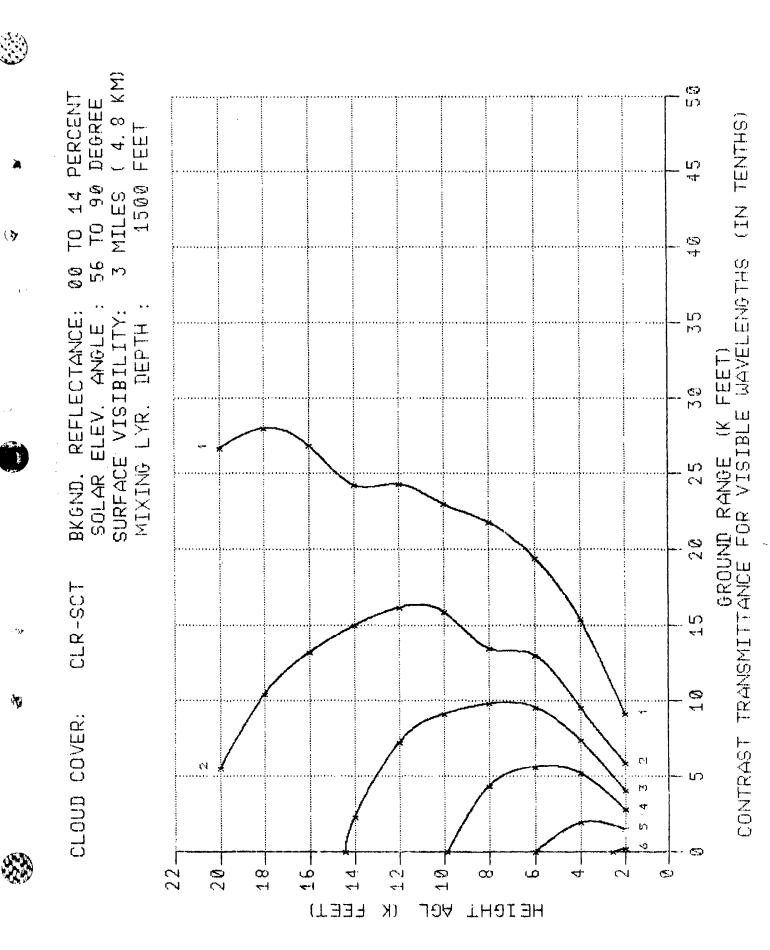
H-150

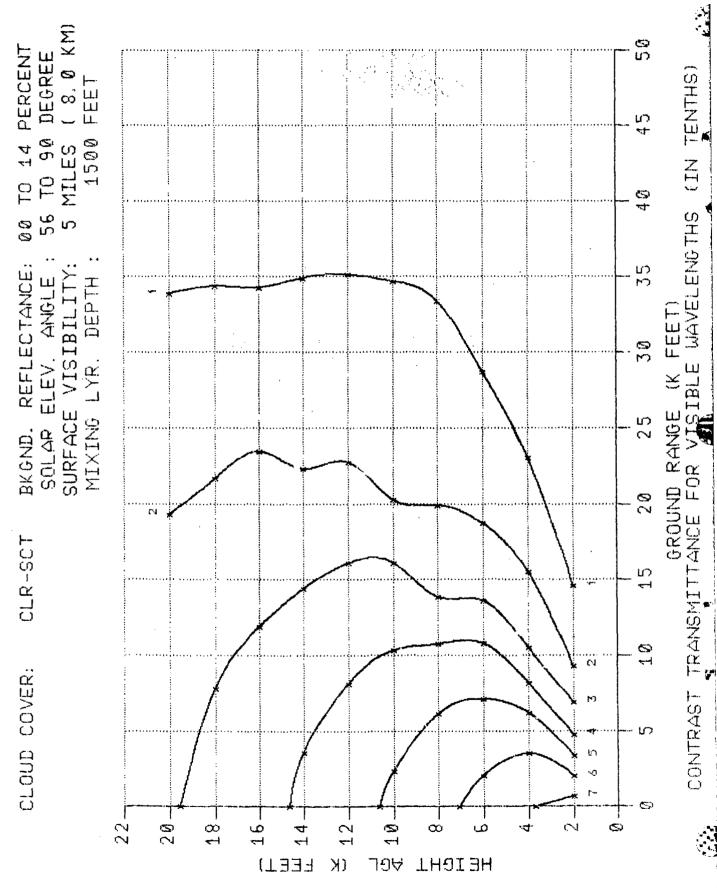


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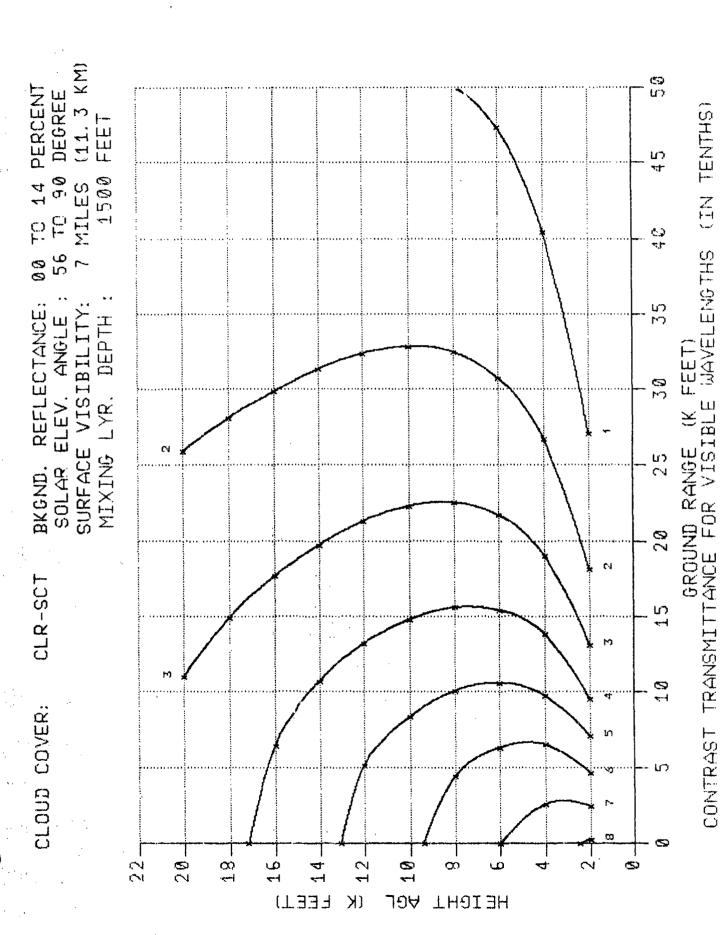


H-152

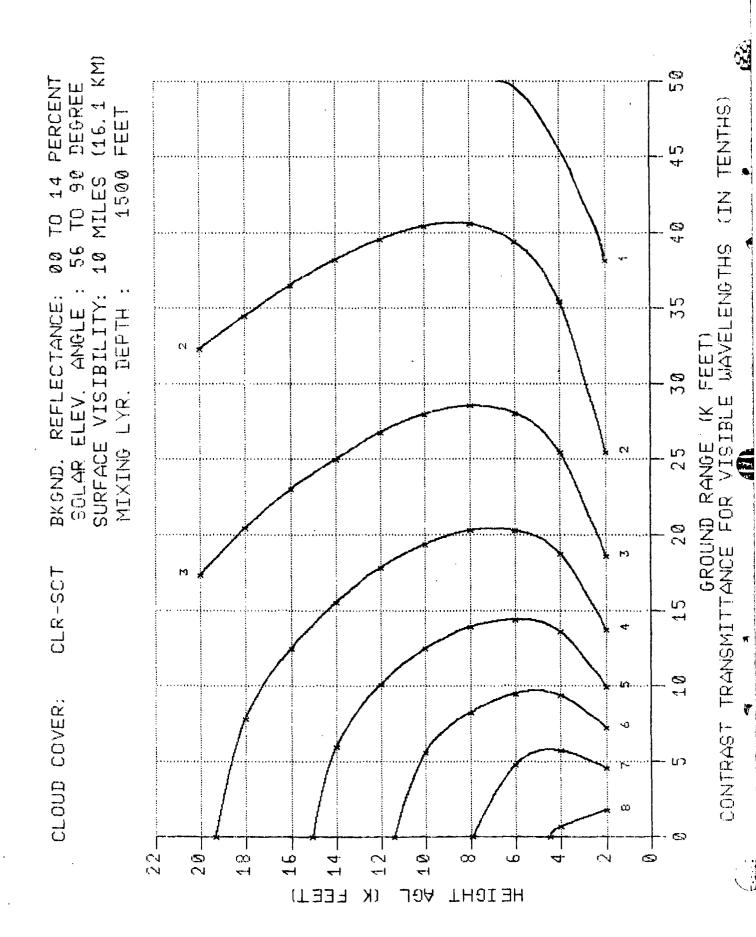




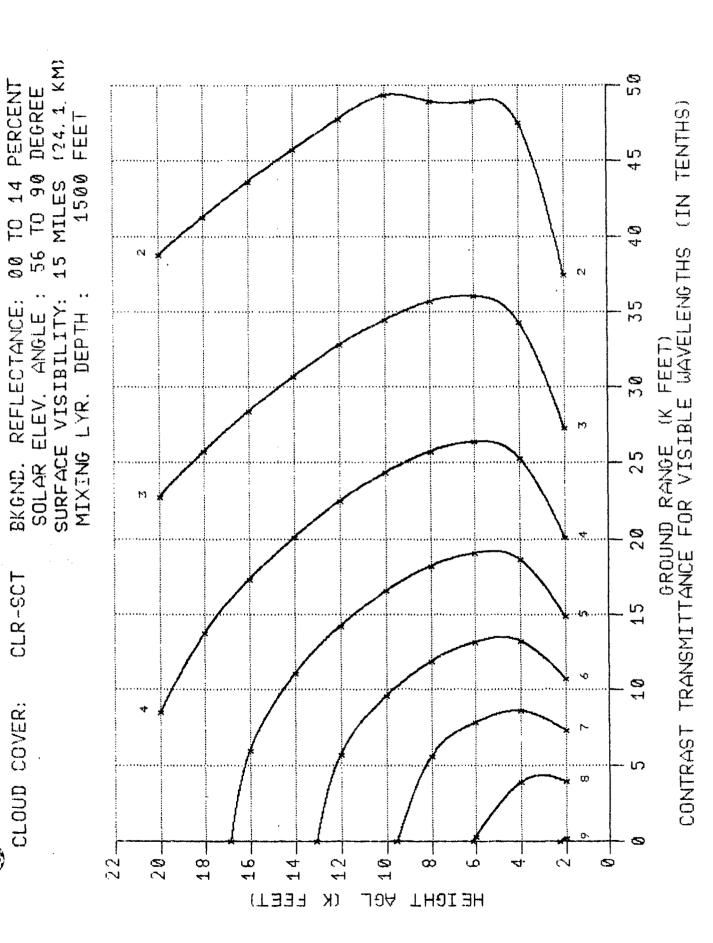
H-154



H-155



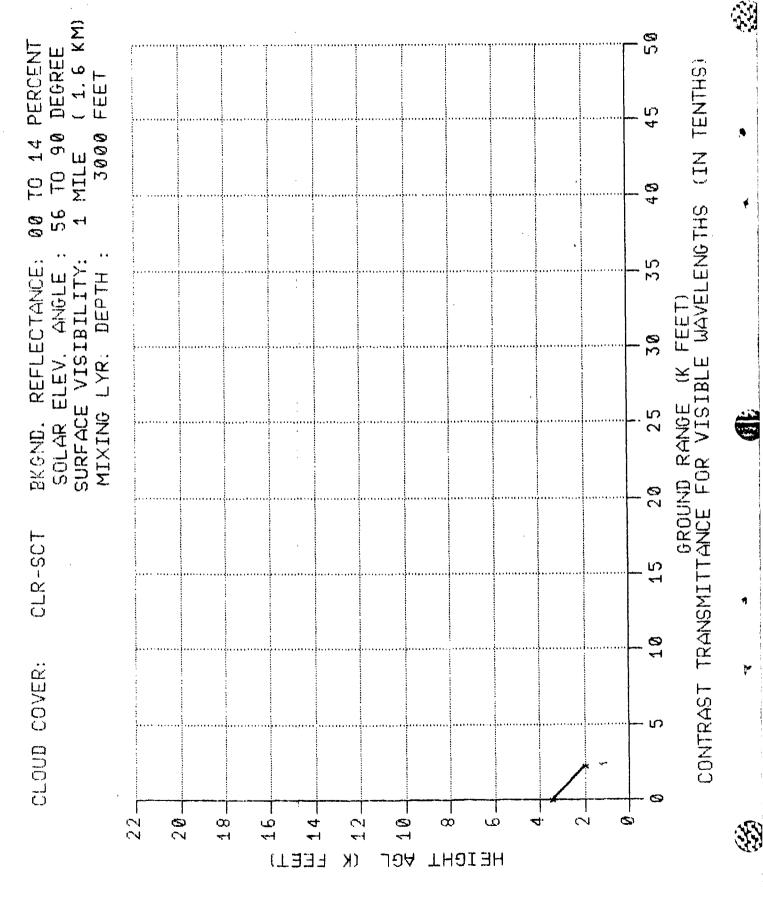
H-156



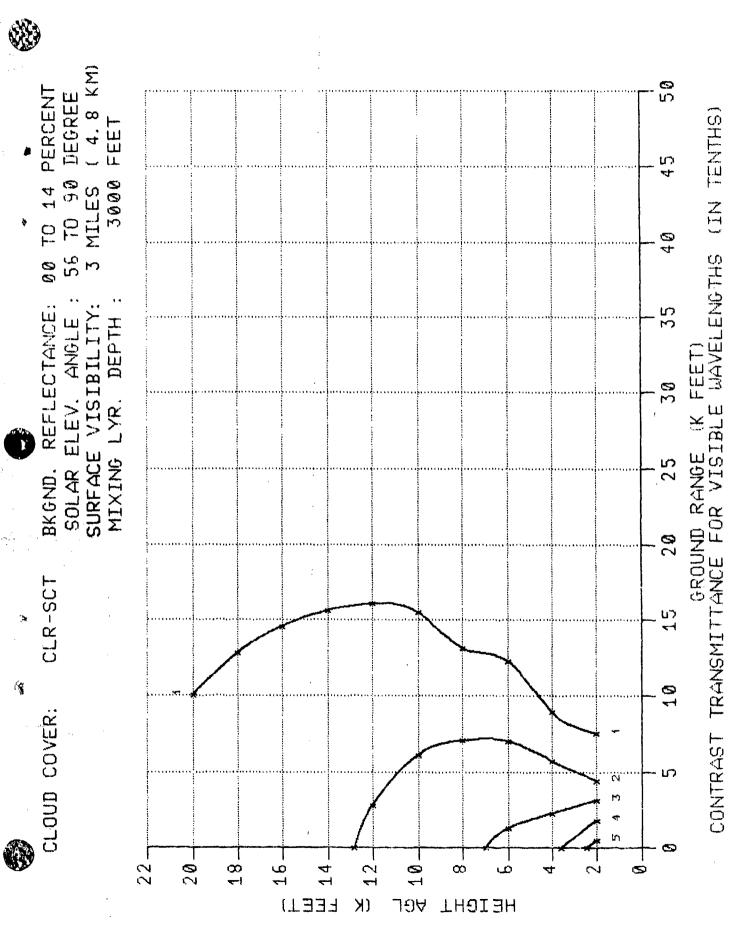
CLR-SCT

CLOUD COVER:

H-157

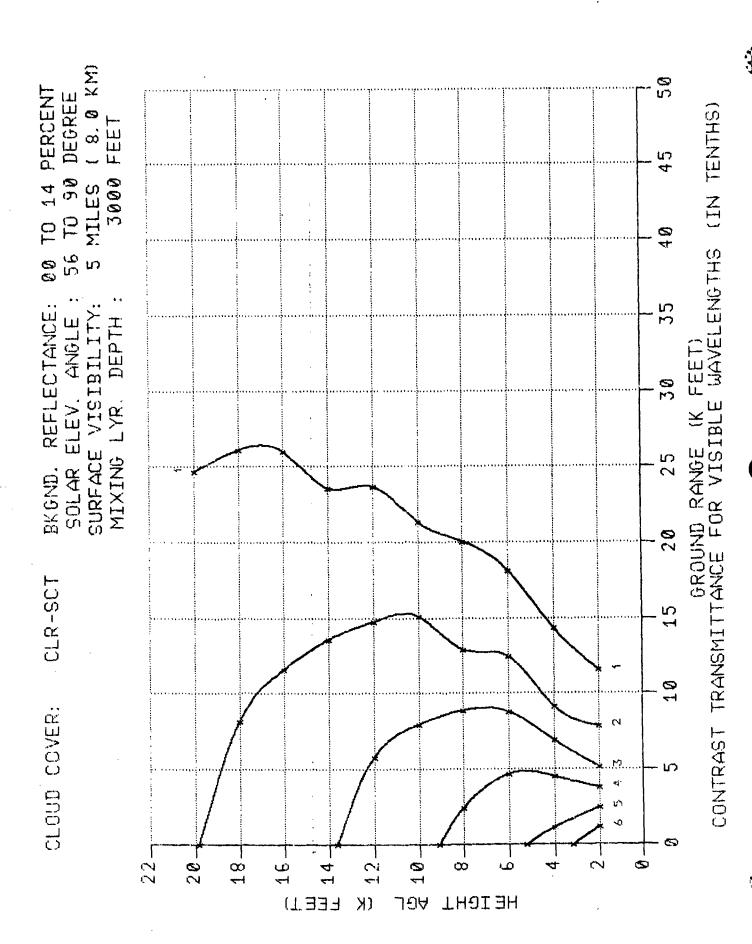


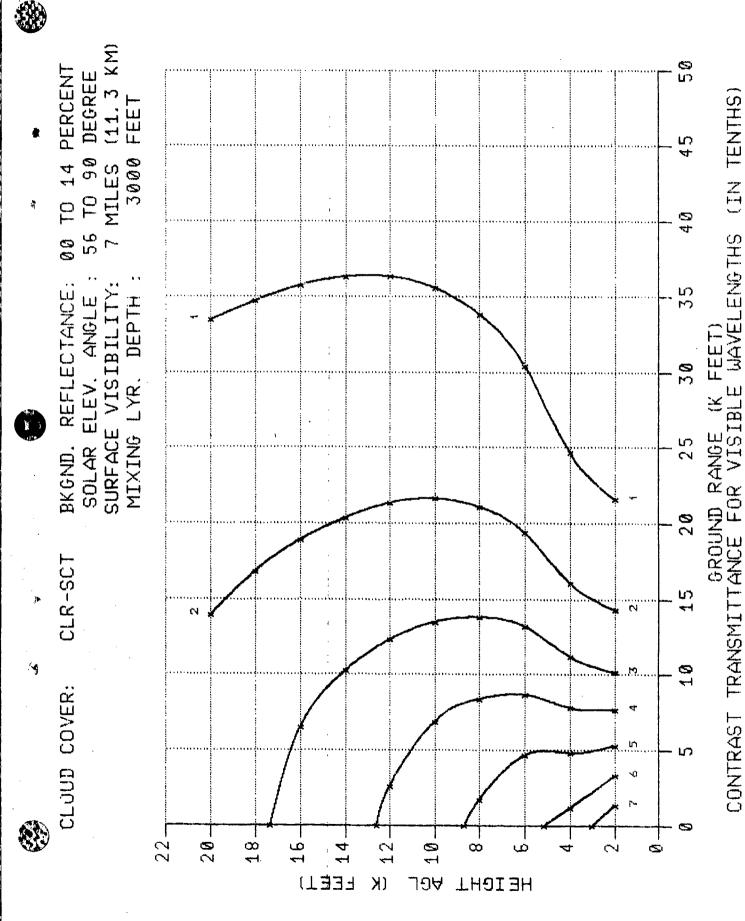
THE THE PARTY OF T



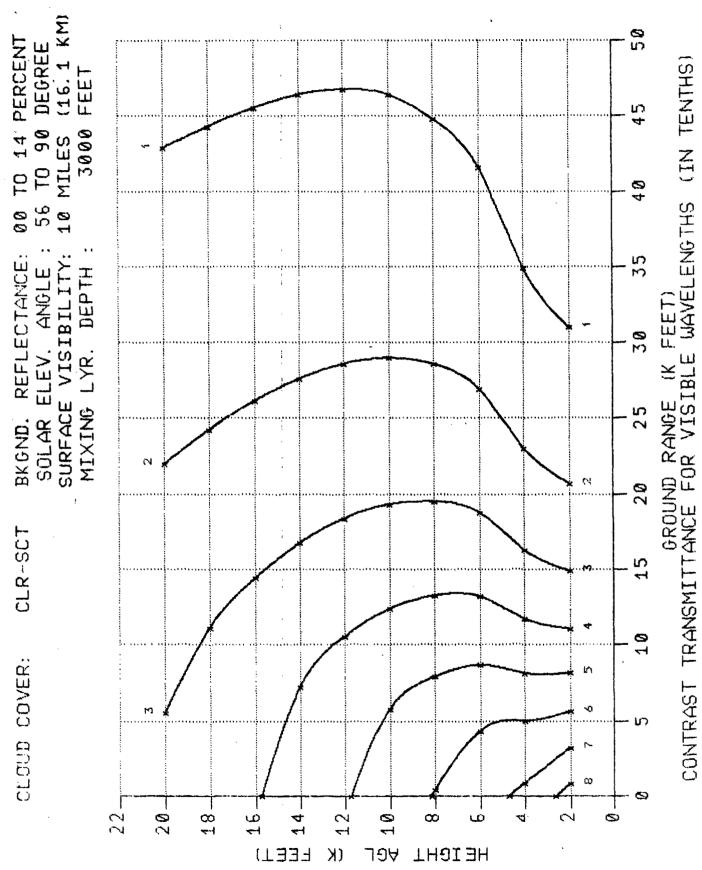
まる人 人名 できる こうしょうしょう

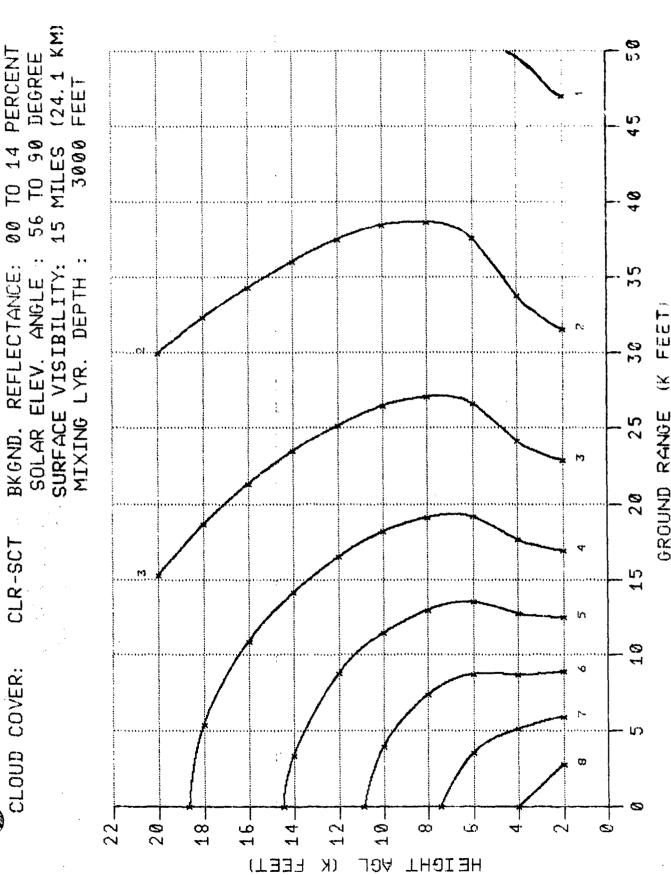
H-159



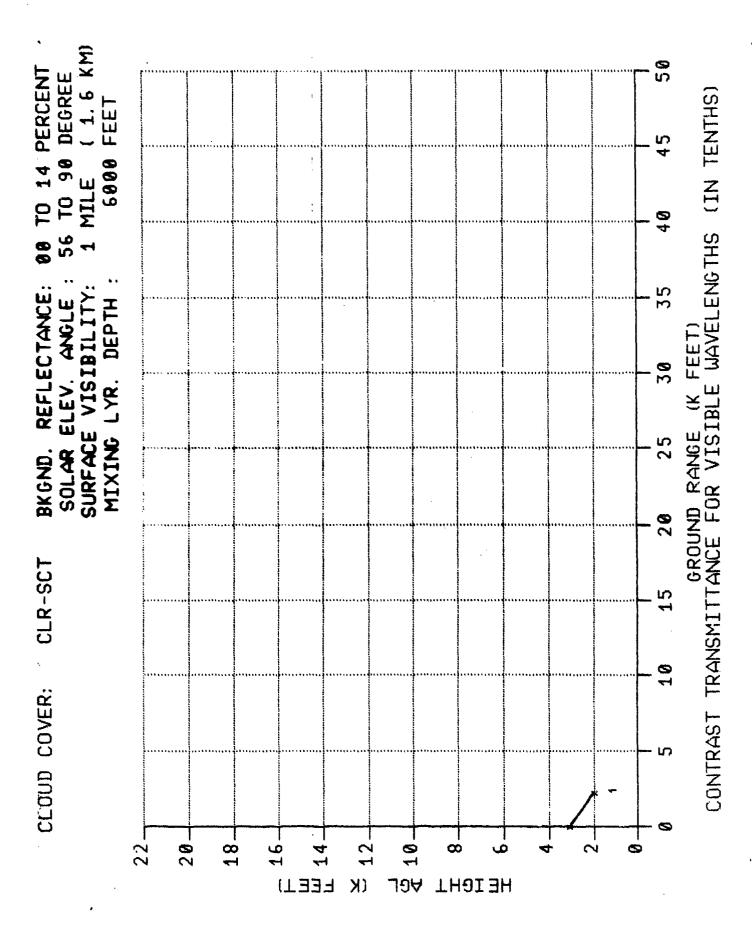


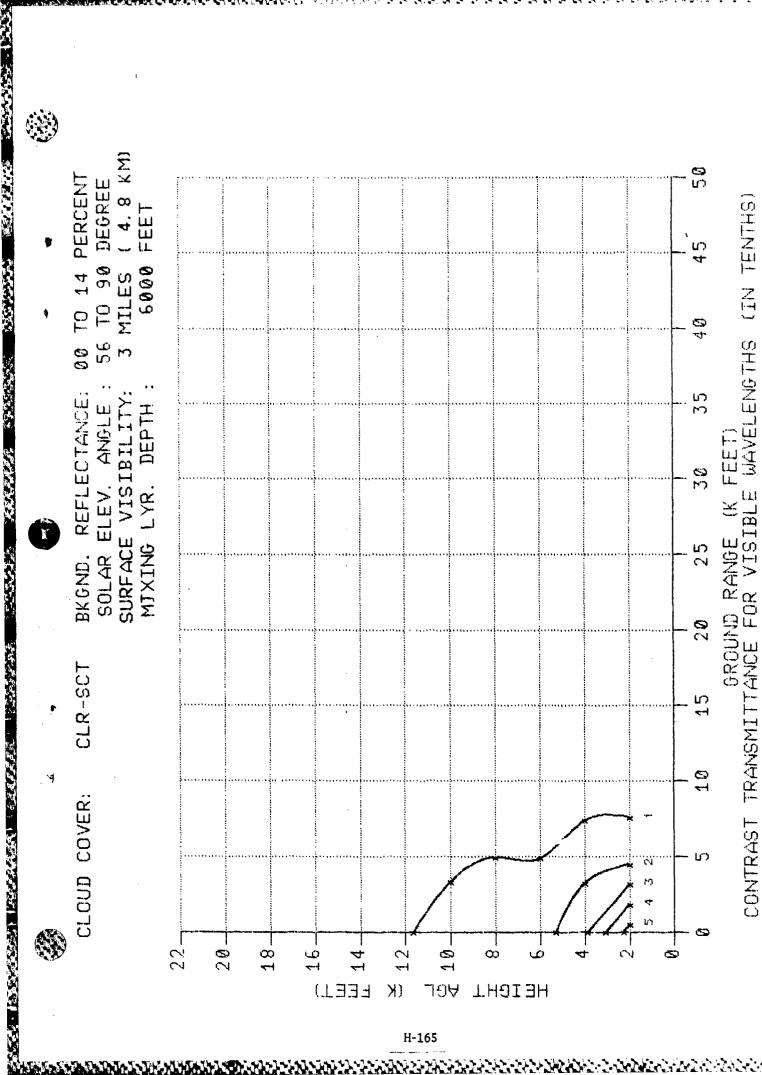
H-161



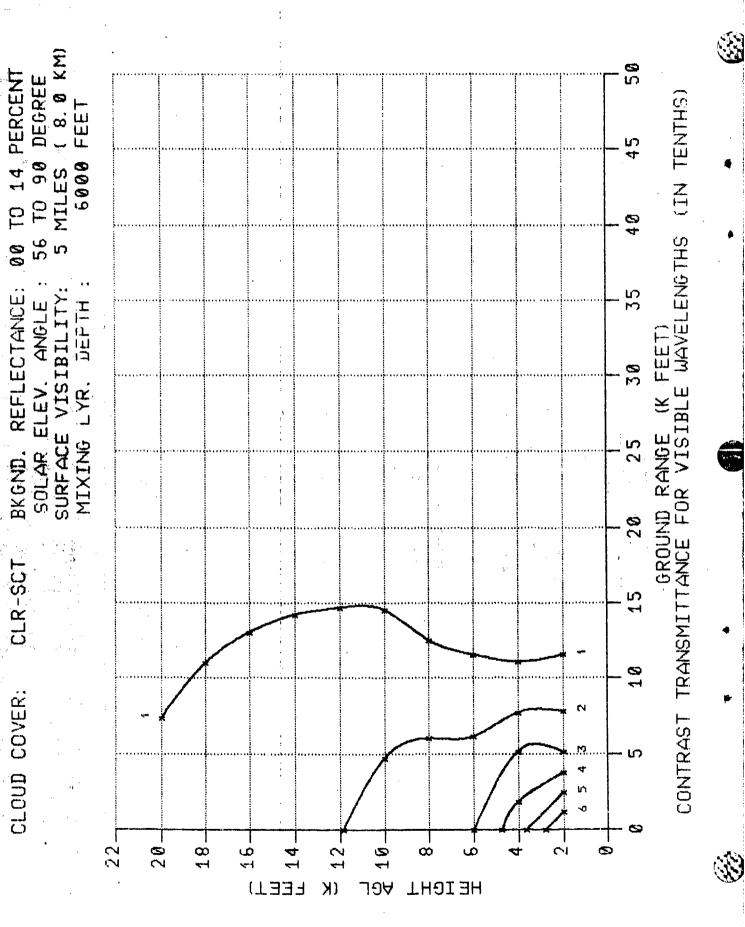


GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE MAVELENGTHS (IN TENTHS)

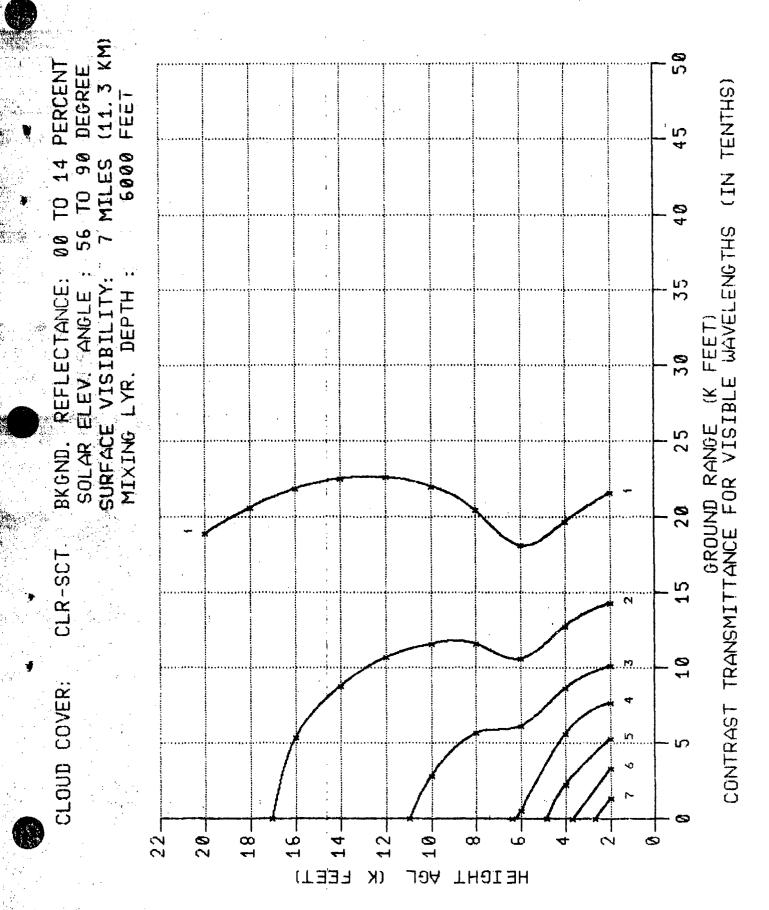




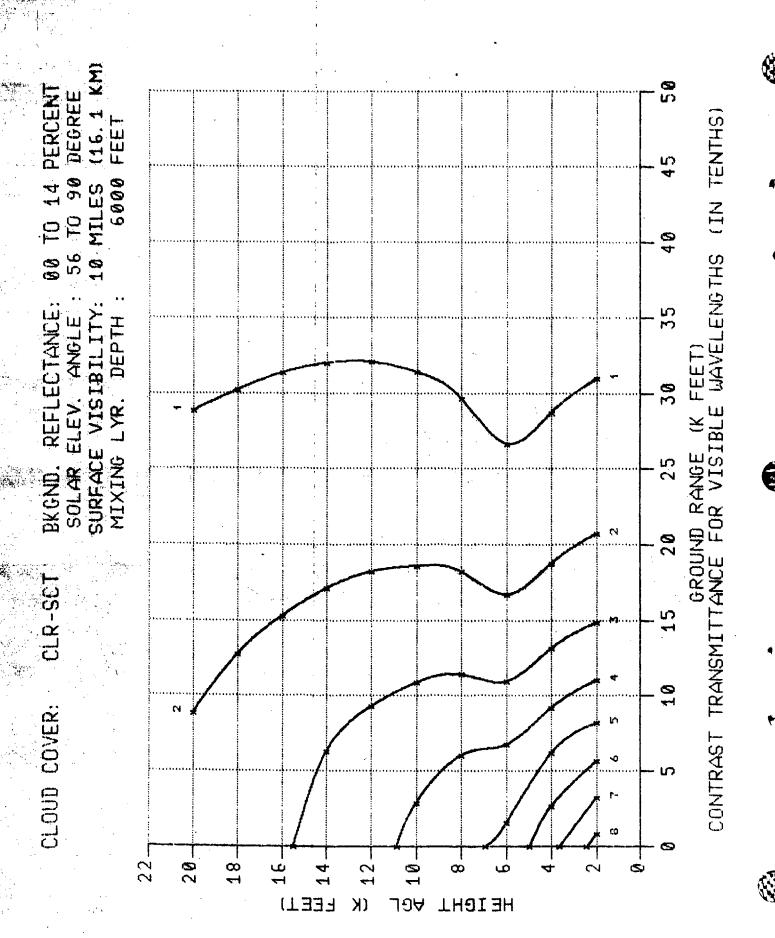
H-165

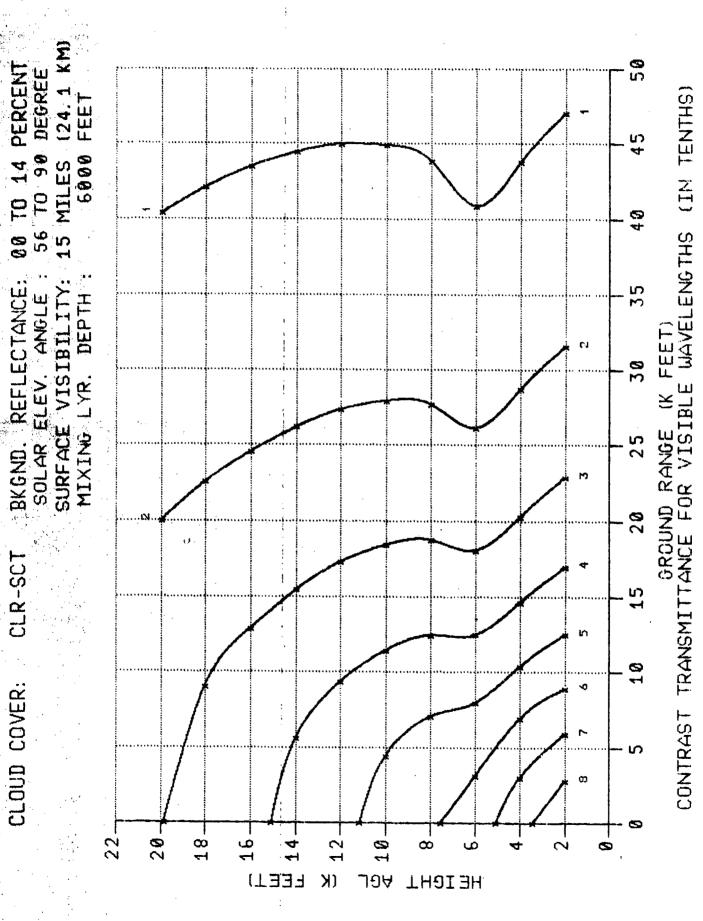


H-166

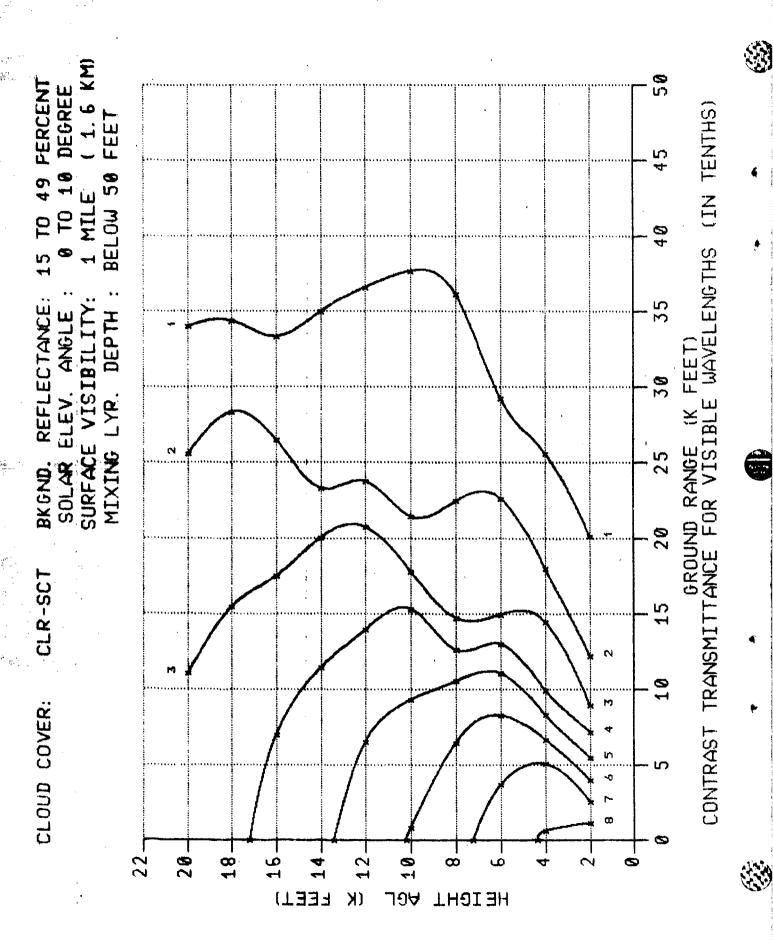


H-167

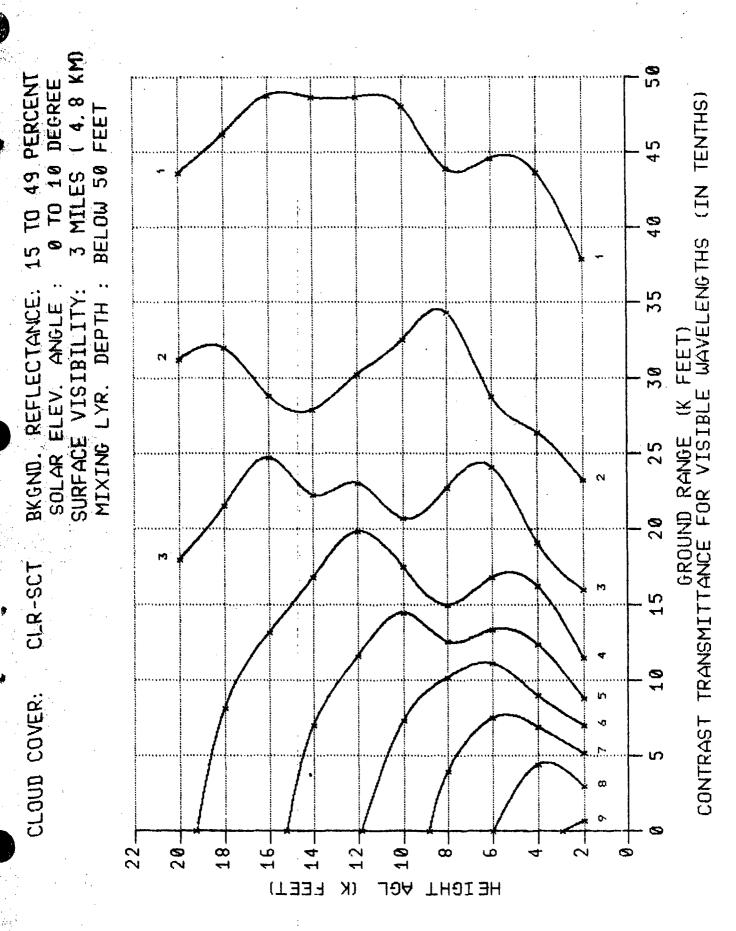




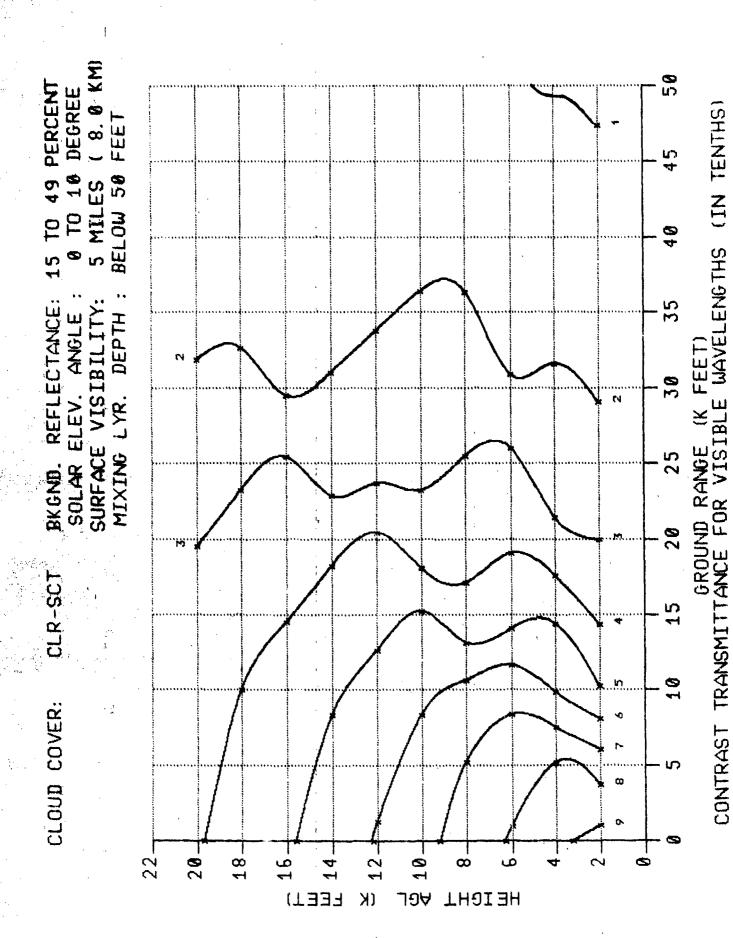
H-169

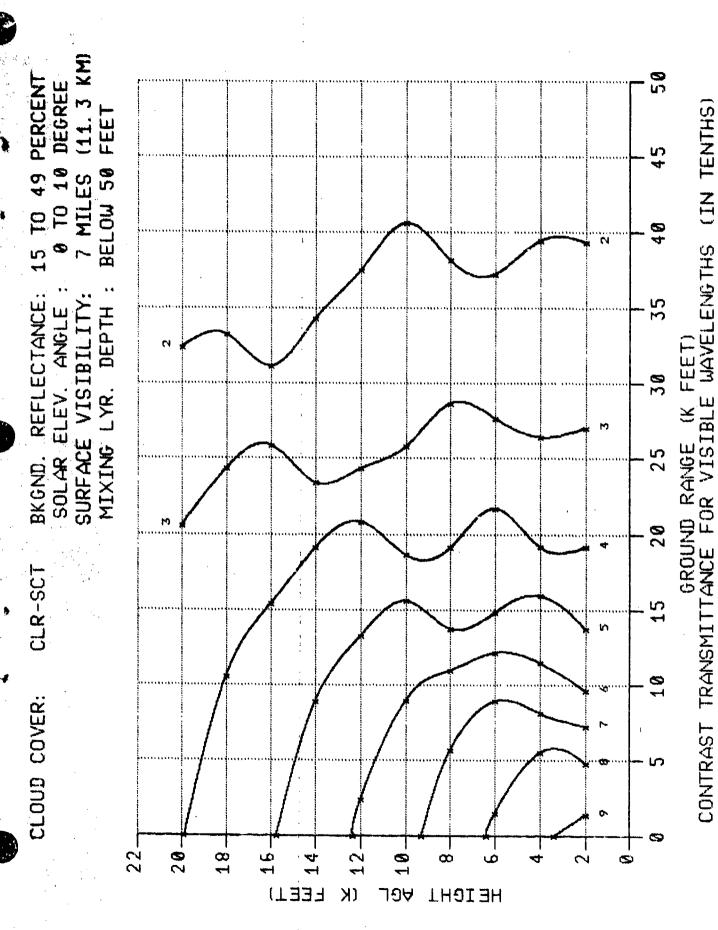


H-170

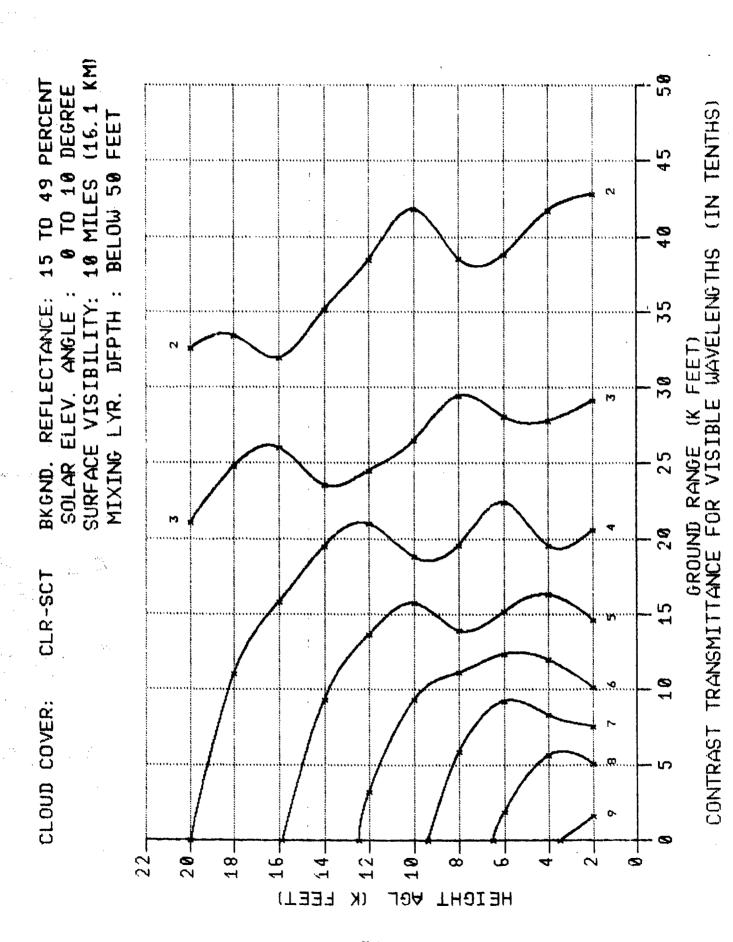


H-171

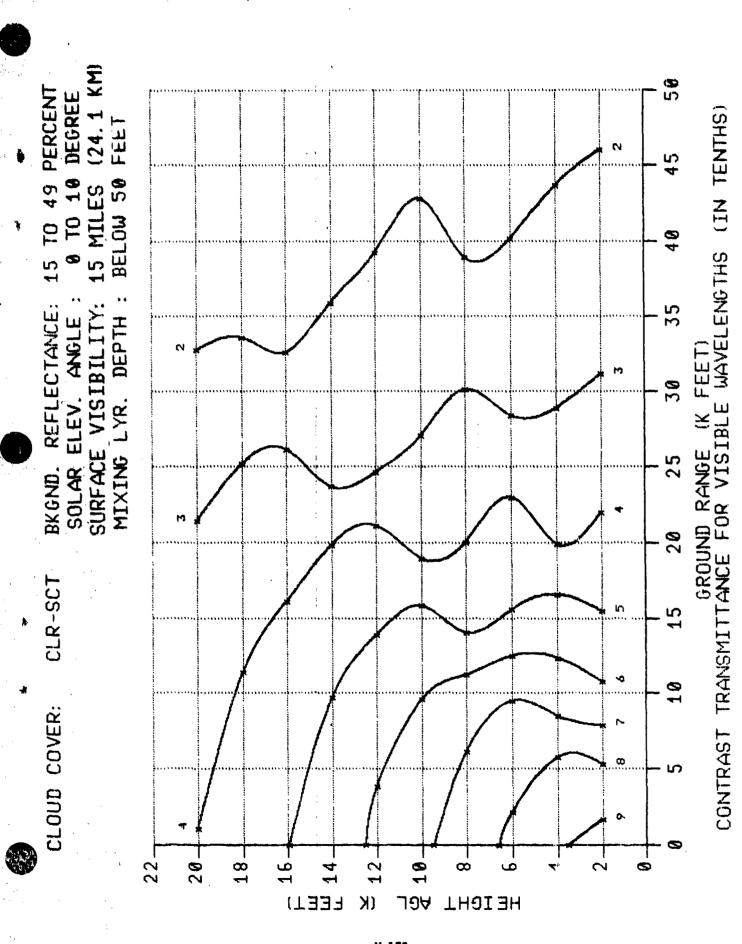




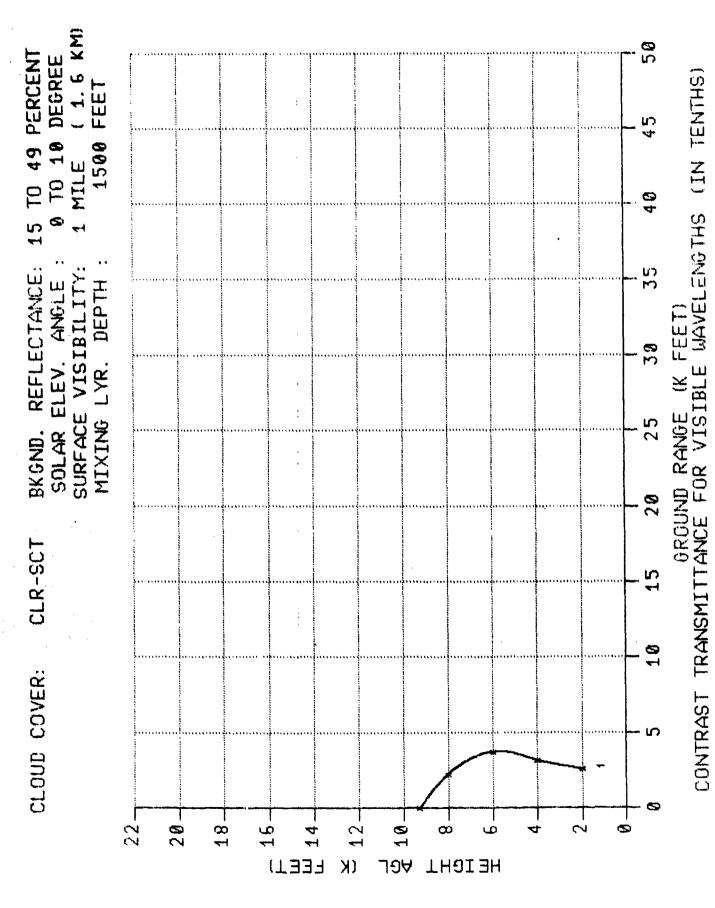
H-173



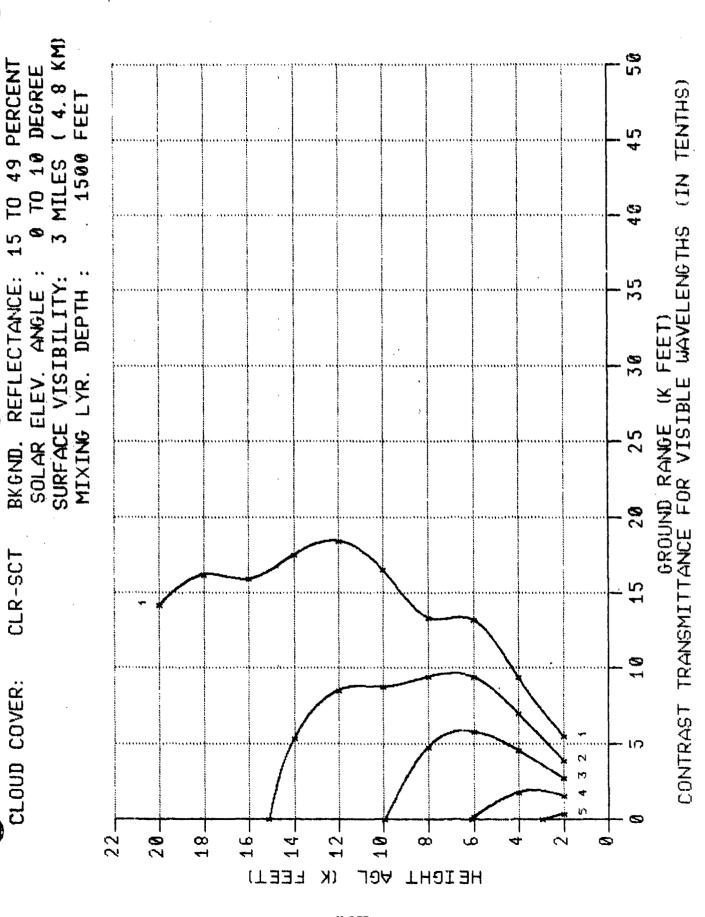
W.



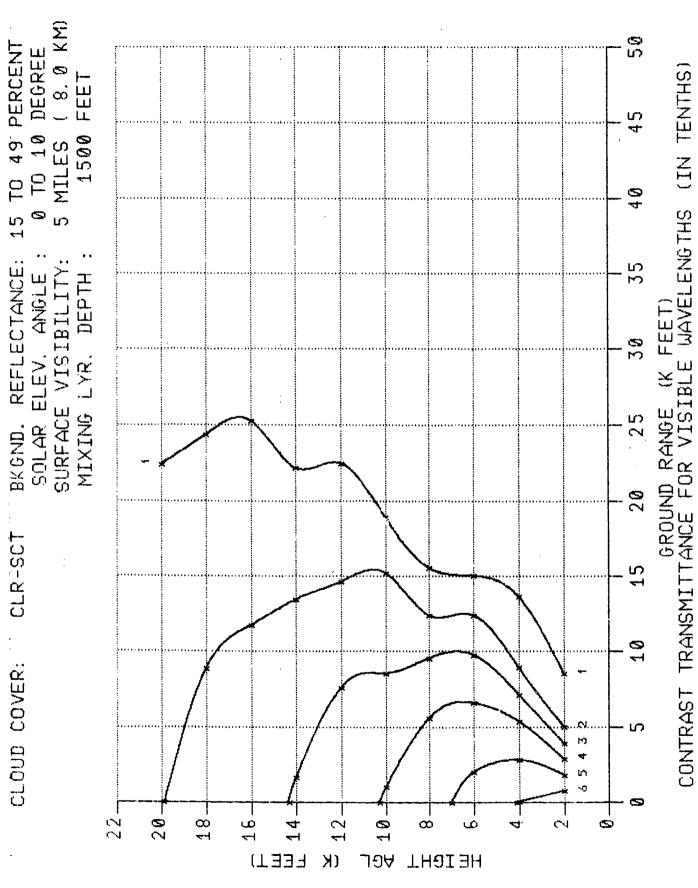
H-175



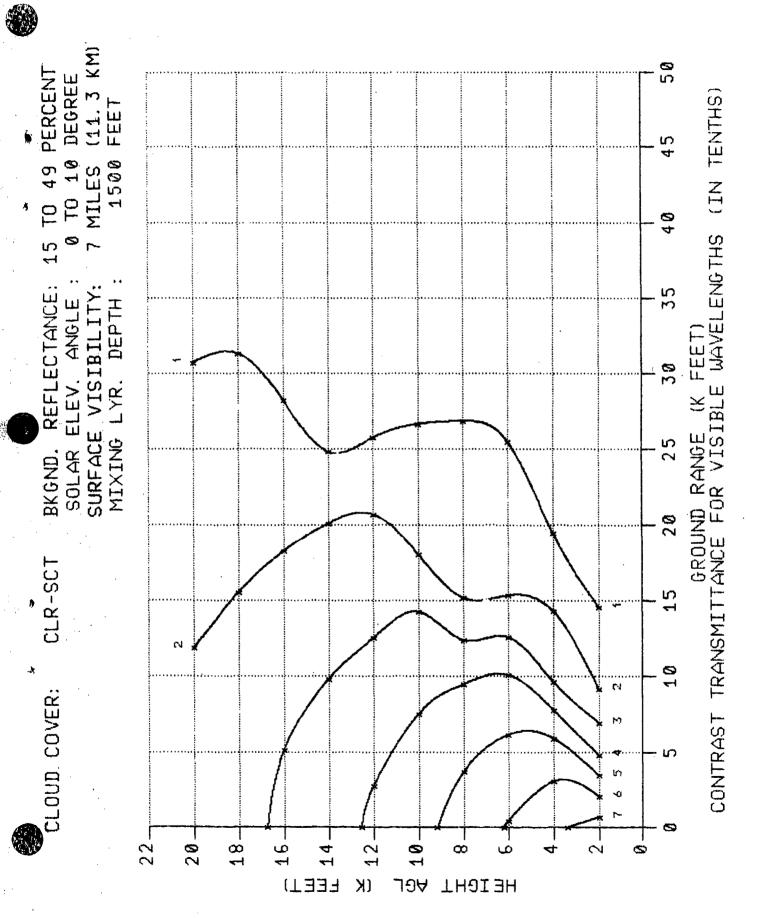
H-176



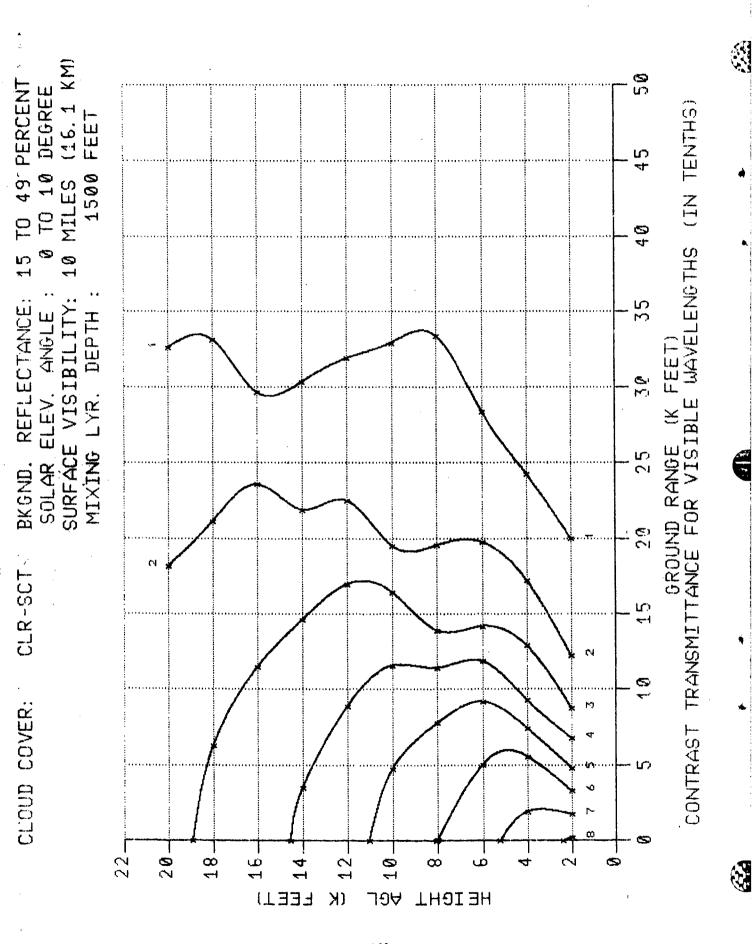
H-177



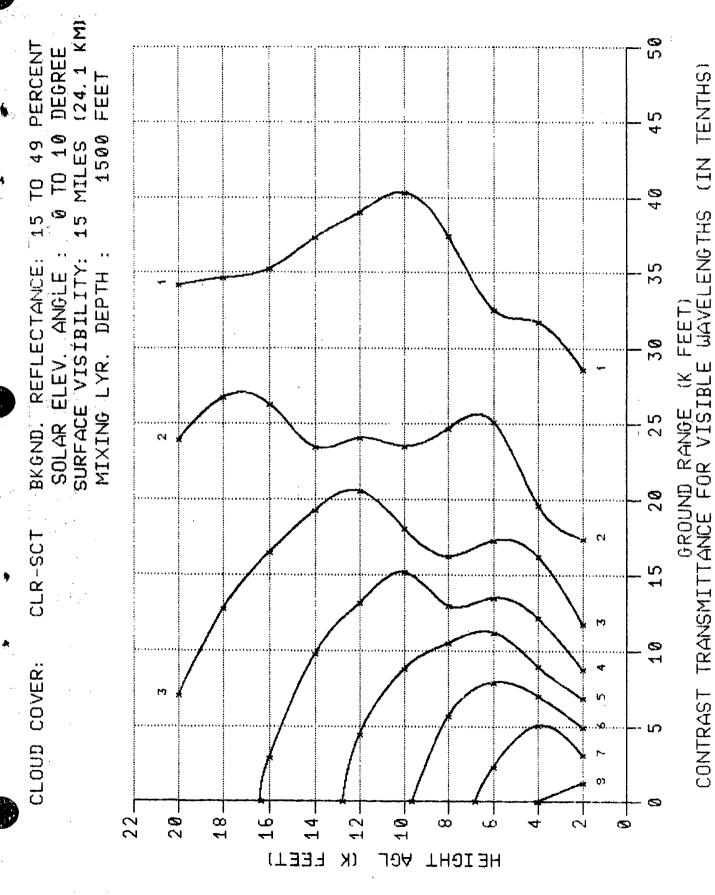
H-178



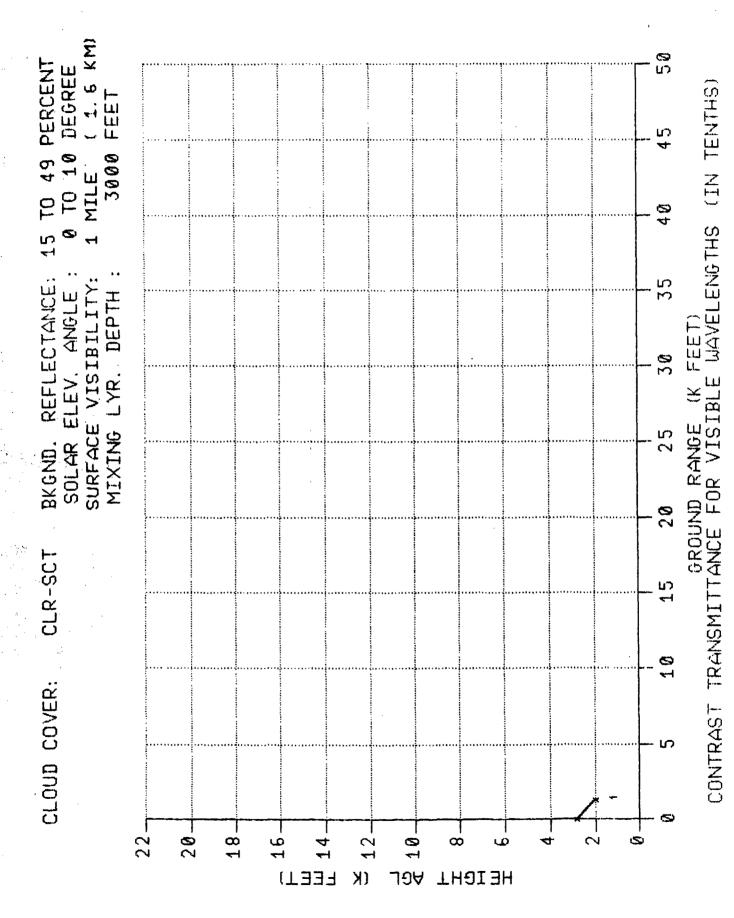
H-179



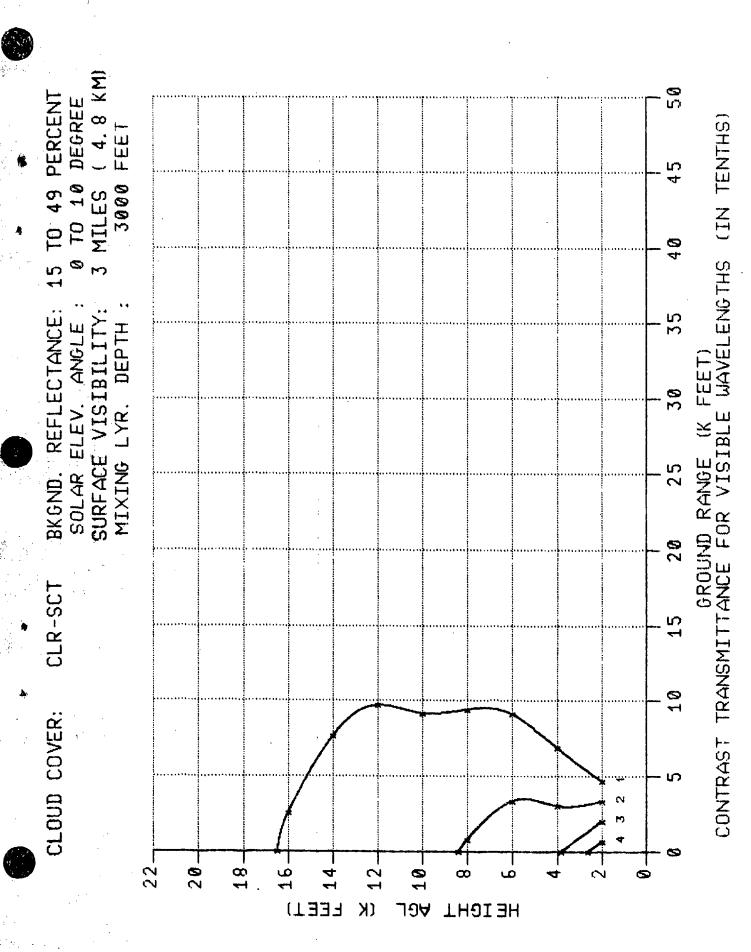
H-180



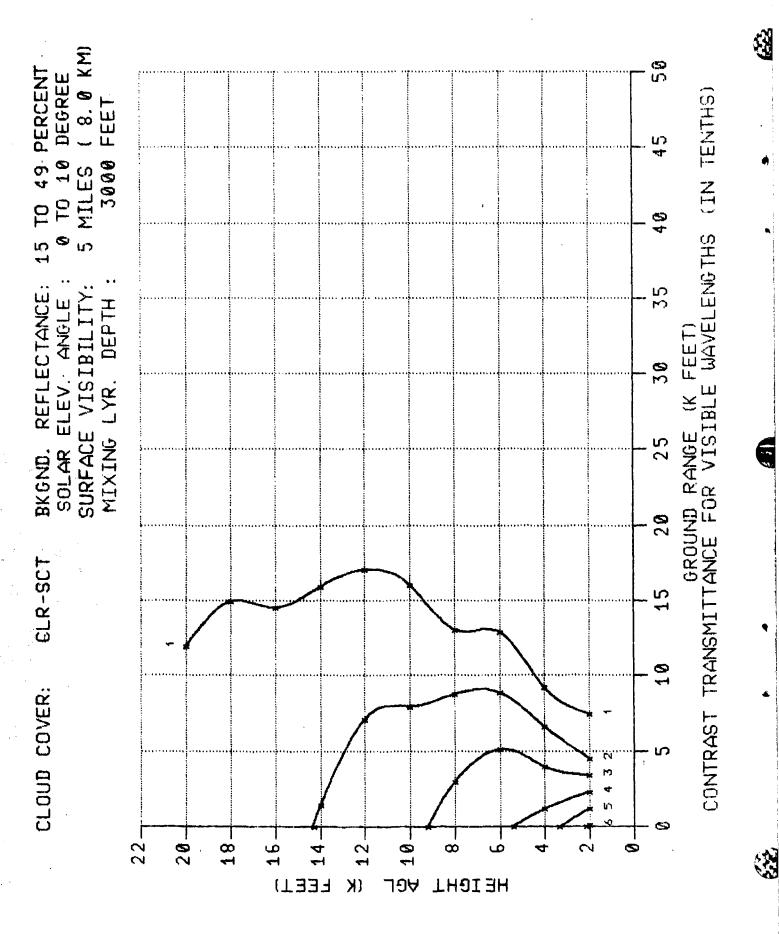
H-181



H-182

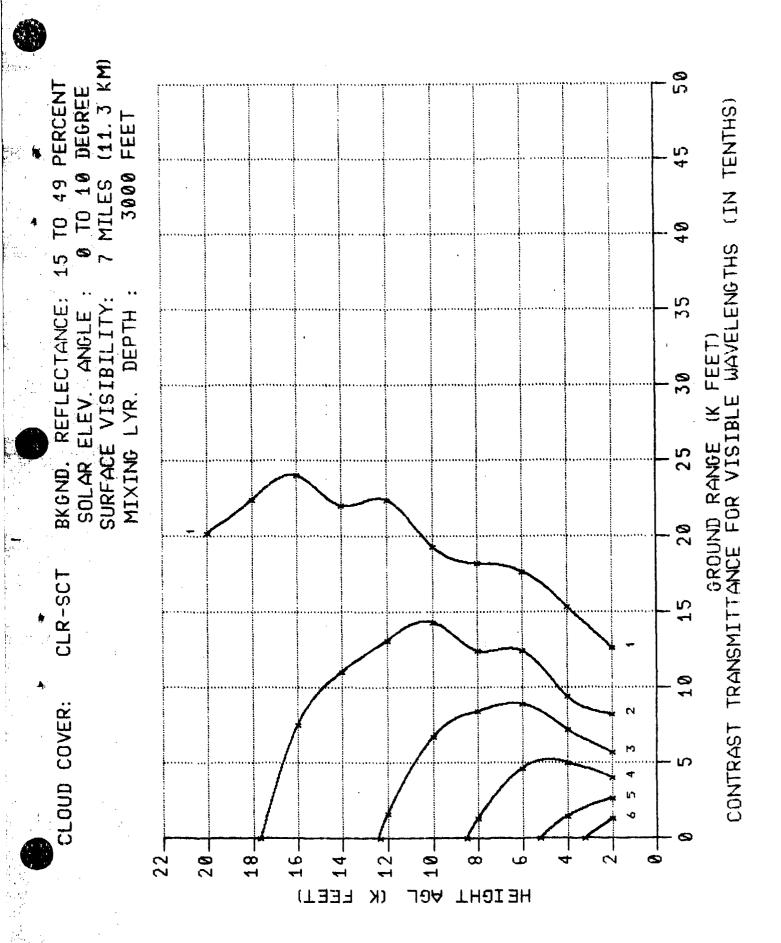


H-183

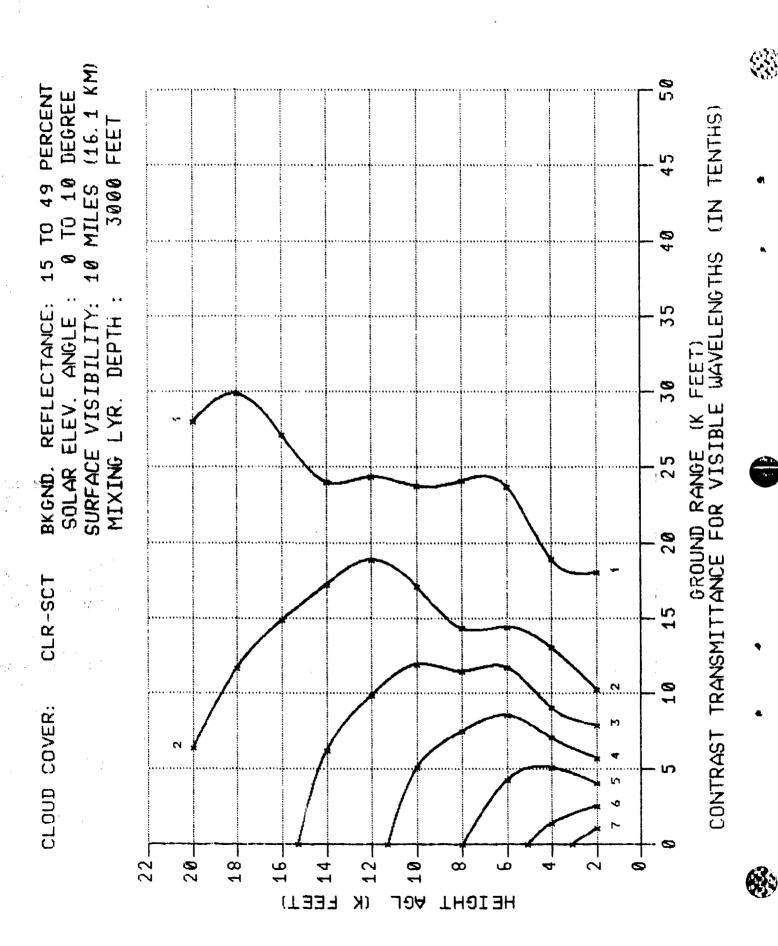


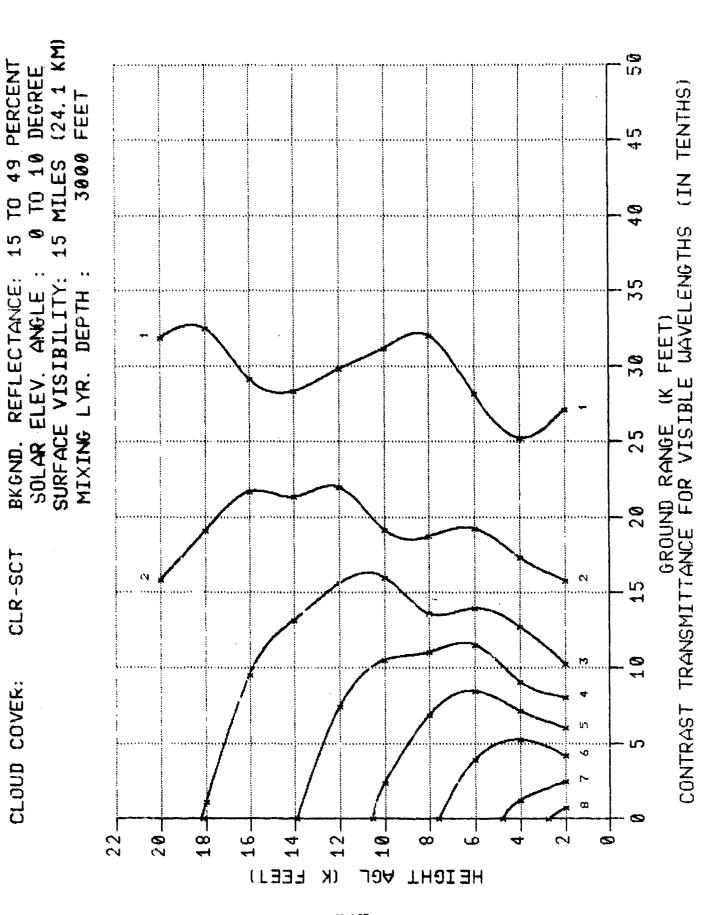
Z.

H-184

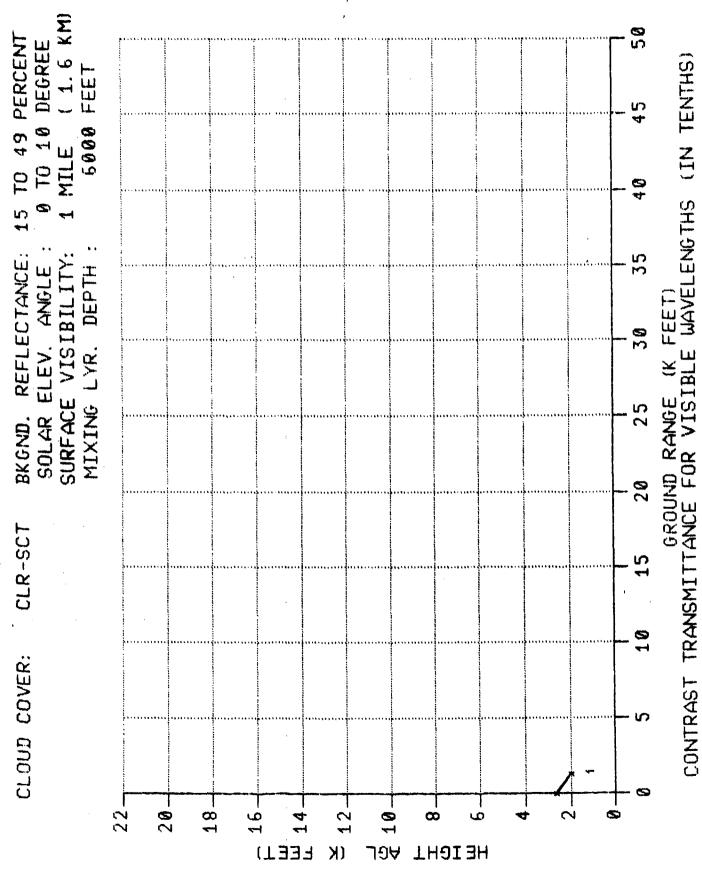


H-185

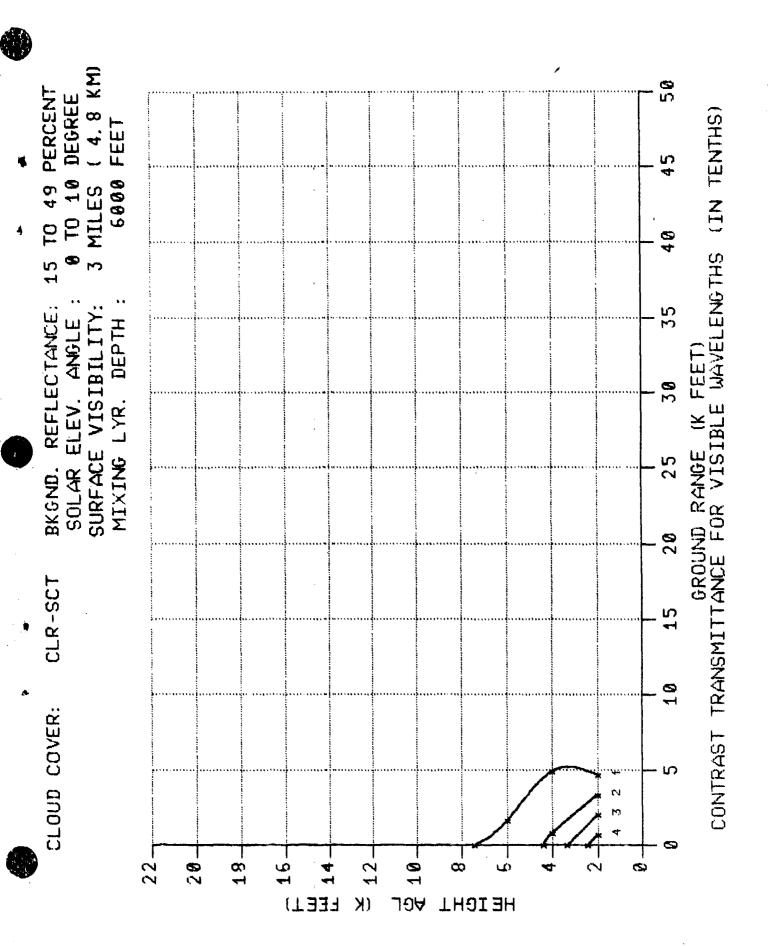




H-187



H-188



H-189

0.0 KM

5 MILES

SURFACE VISIBILITY: SOLAR ELEV. ANGLE

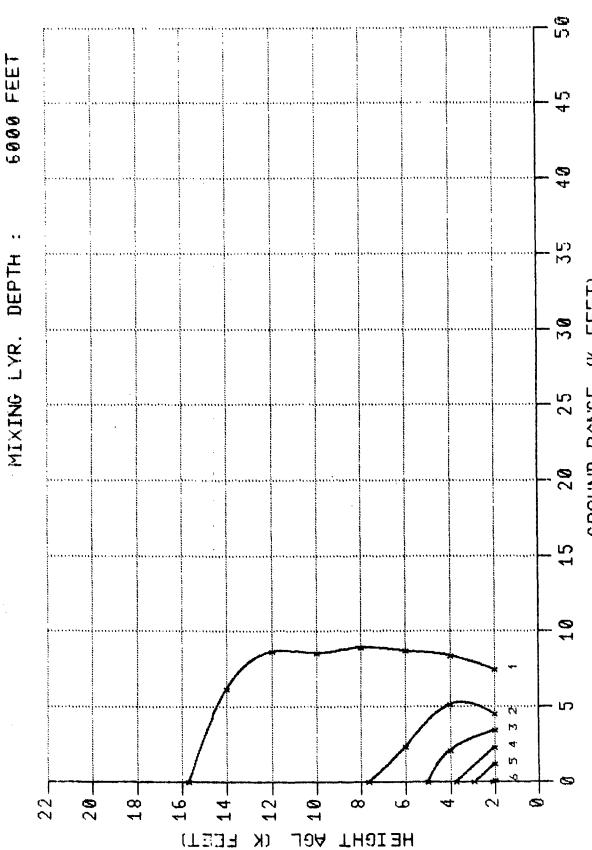
15 TO 49 PERCENT 0 TO 10 DEGREE

BKGND, REFLECTANCE:

CLR-SCT

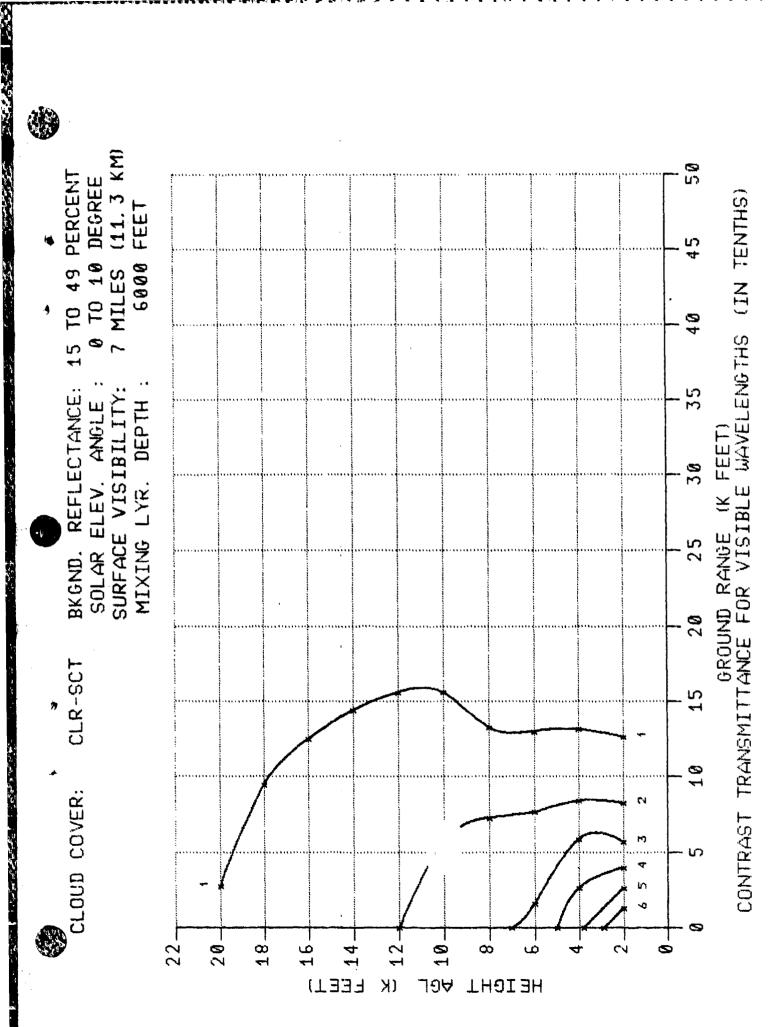
CLOUD COVER:

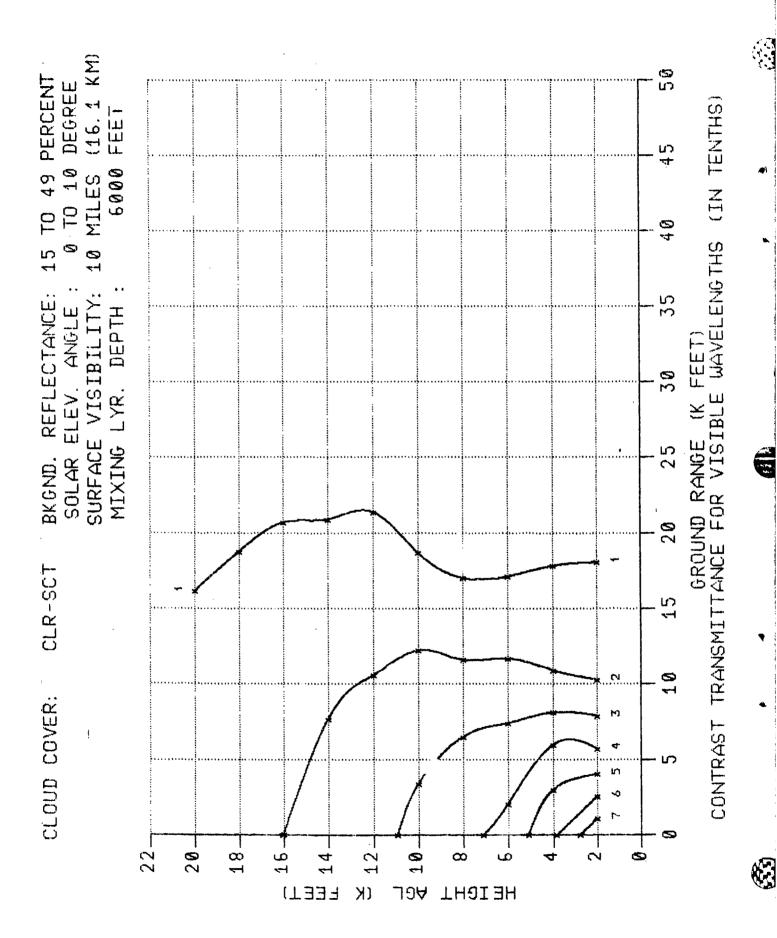
¥



GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

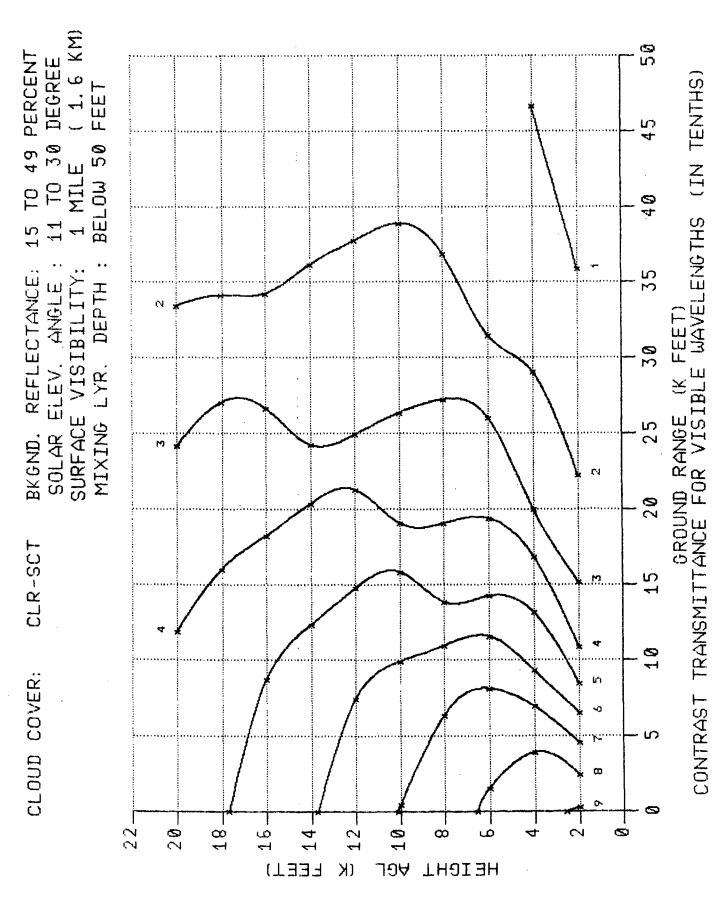
(6)





H-192

χ Σ 3 3 TO 49 PERCENT TO 10 DEGREE (24.1GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) 上五五五 47 (J) 0009 15 MILES 4 6 <del>1</del> (3) MIXING LYR. DEPTH : REFLECTANCE: SOLAR ELEV. ANGLE SURFACE VISIBILITY: м СП 30 25 BKGND. 20 CLR-SCT 15 6 6 7 CLOUD COVER: ហ 22 -20-18-16-4.0 9 14 42  $\infty$ മ 4  $\sim$ FEET ٦Đ∀ (K тноган



H-194

 $\Sigma$ 15 TO 49 PERCENT 11 TO 30 DEGREE 3 MILES ( 4.8 KM BELOW 50 FEET MIXING LYR. DEPTH : BKGND, REFLECTANCE: SOLAR ELEV. ANGLE SURFACE VISIBILITY CLR-SCT CLOUD COVER: 22 -200-LEET) 18-10-

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

9

40

35

30

20

15

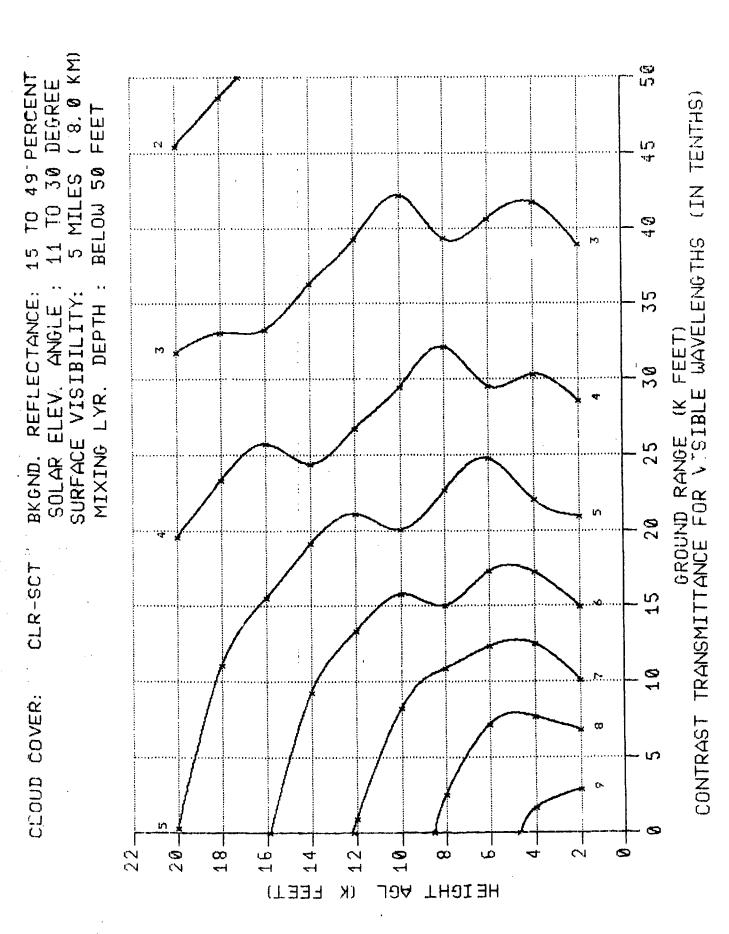
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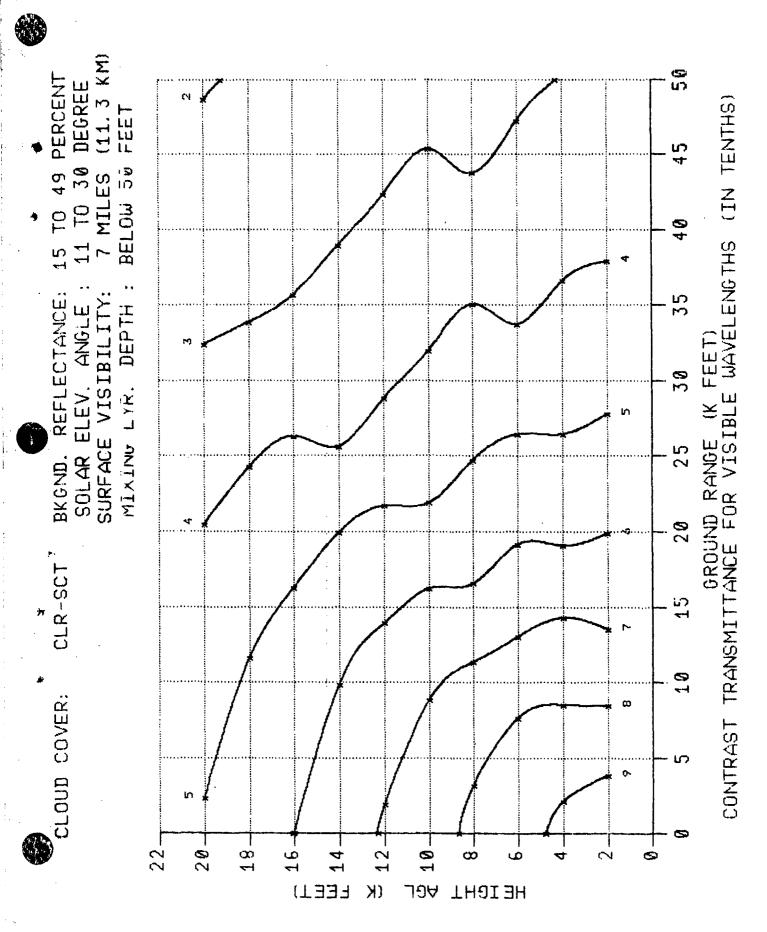
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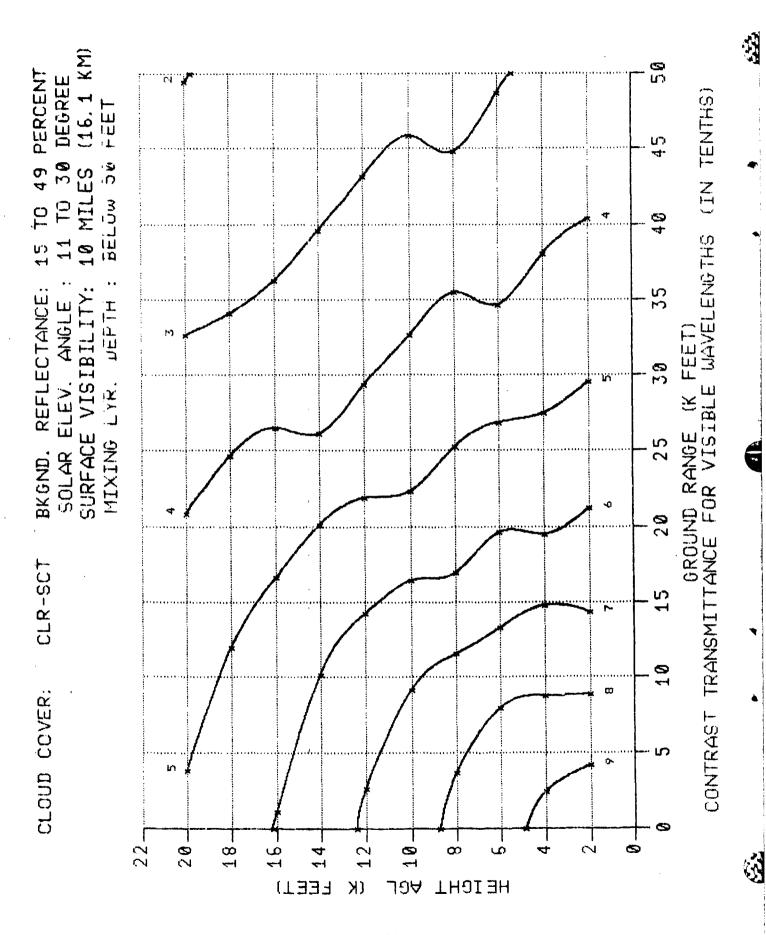
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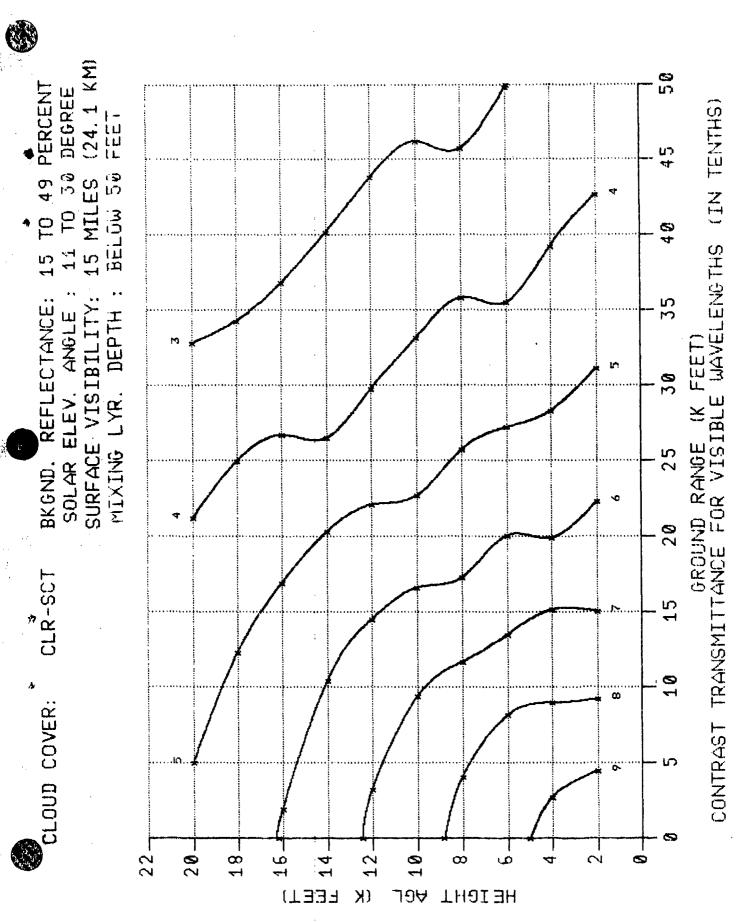
H-196

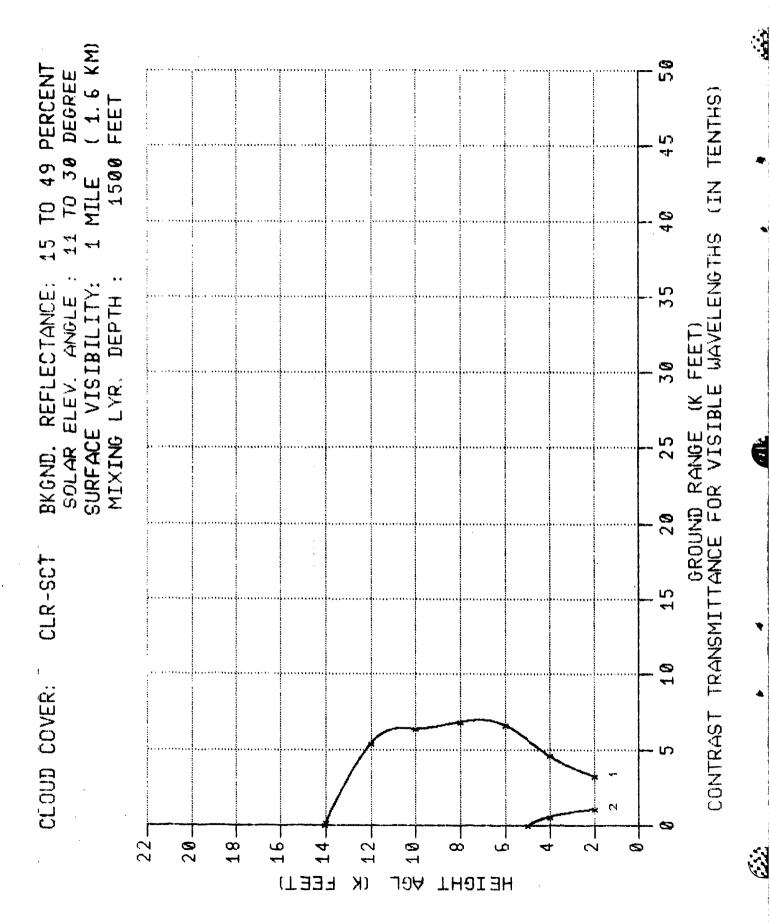


H-197



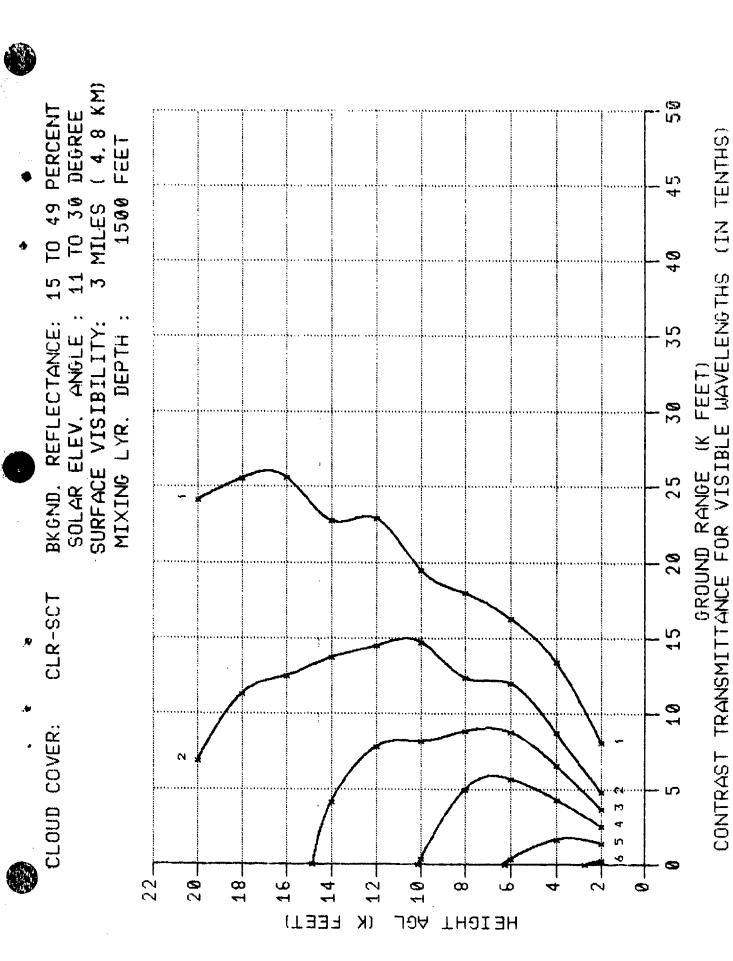
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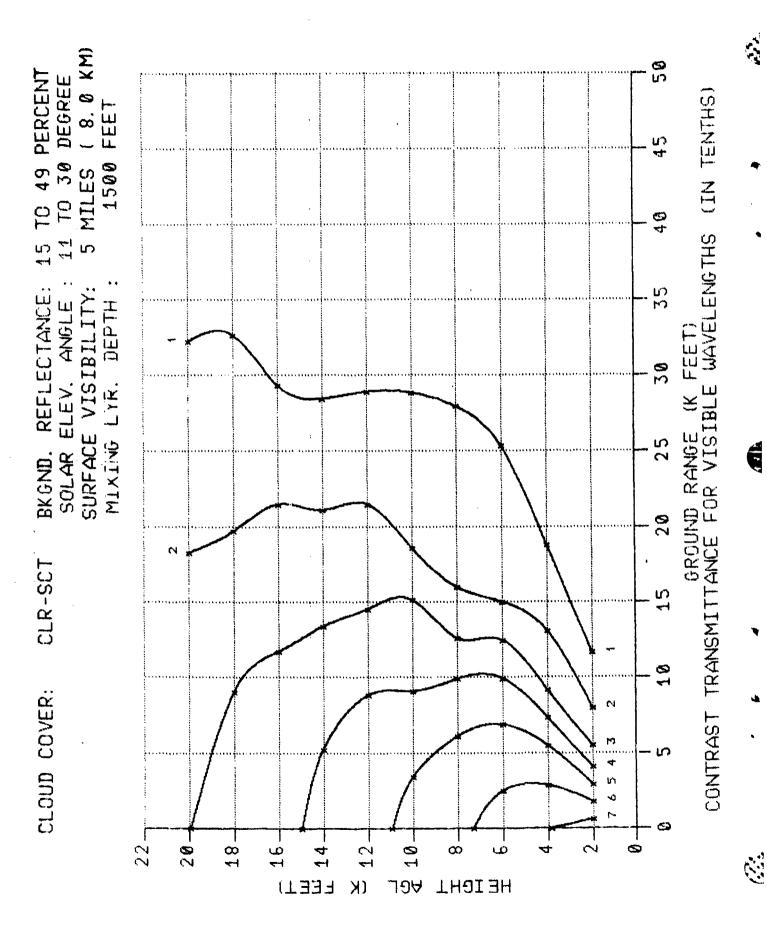




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H-200





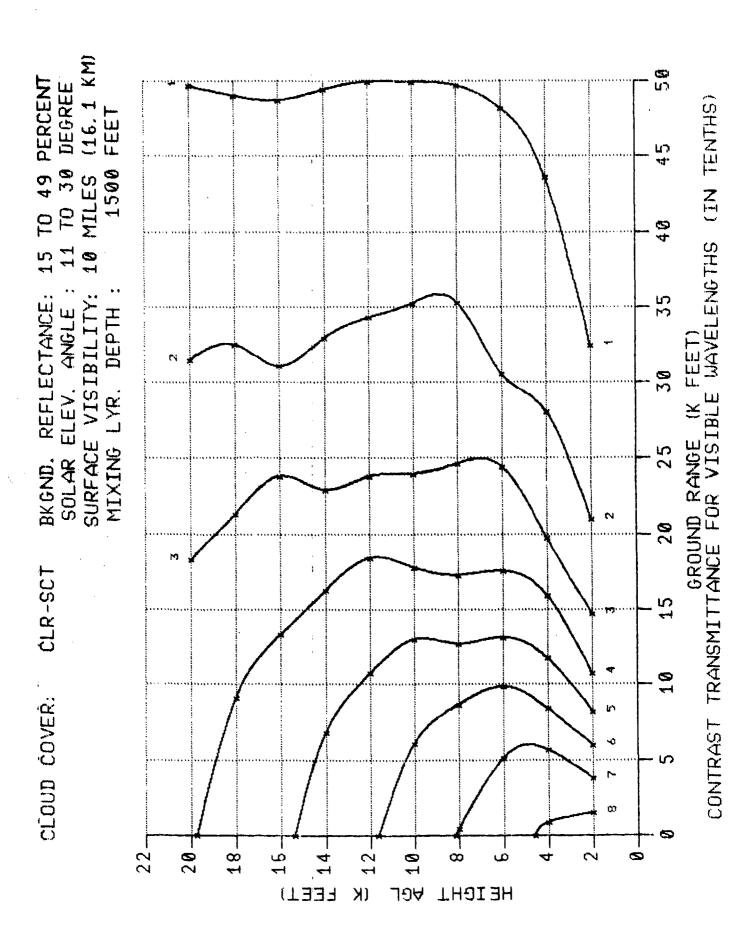
TO 49 PERCENT TO 30 DEGREE

BKGND. REFLECTANCE:

CLR-SCT

CLOUD COVER:

H-203



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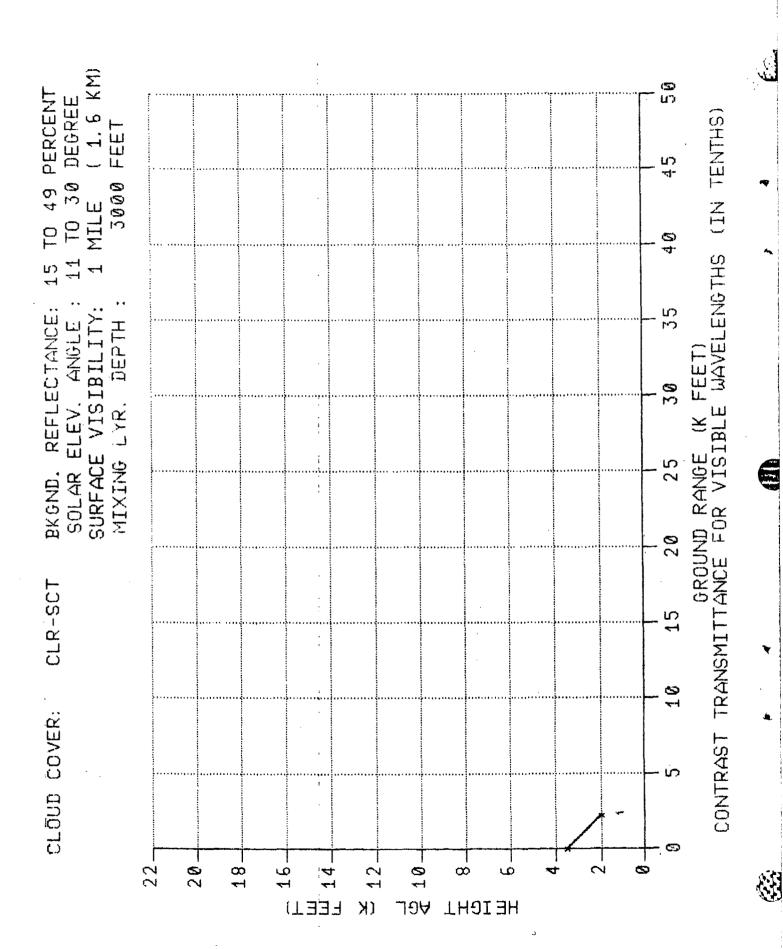
15 TO 49 PERCENT

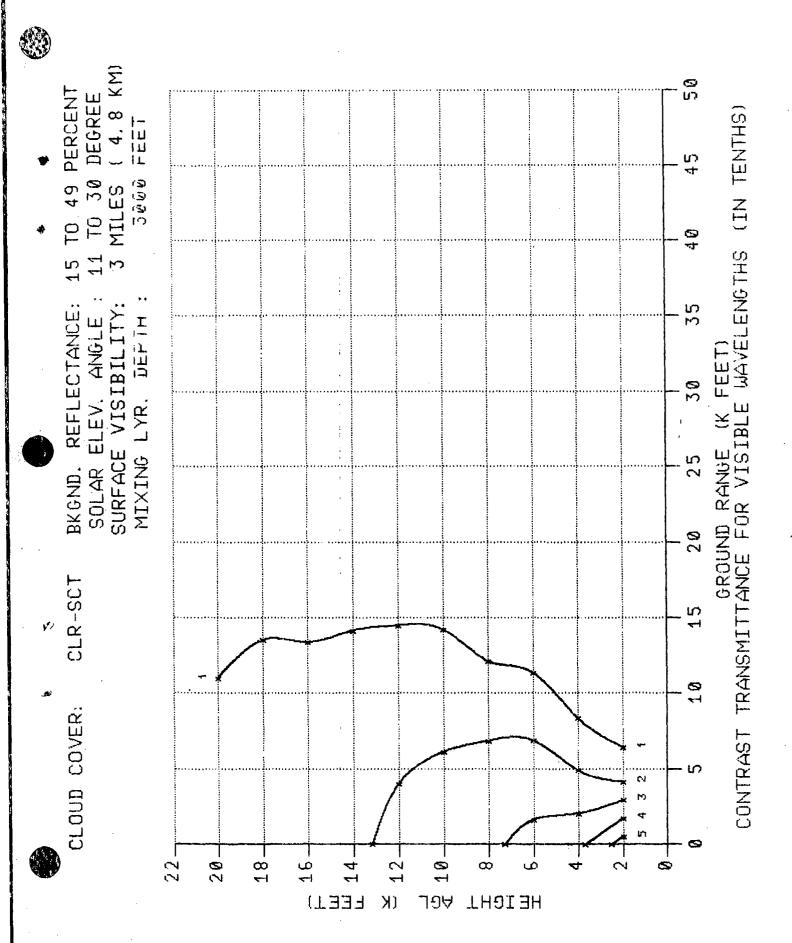
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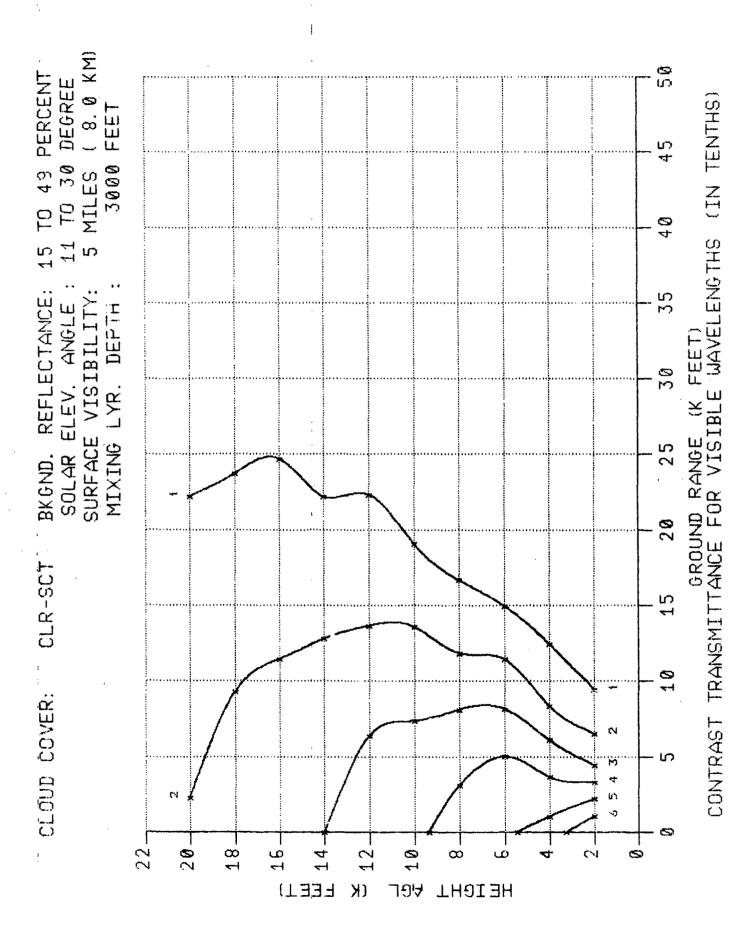
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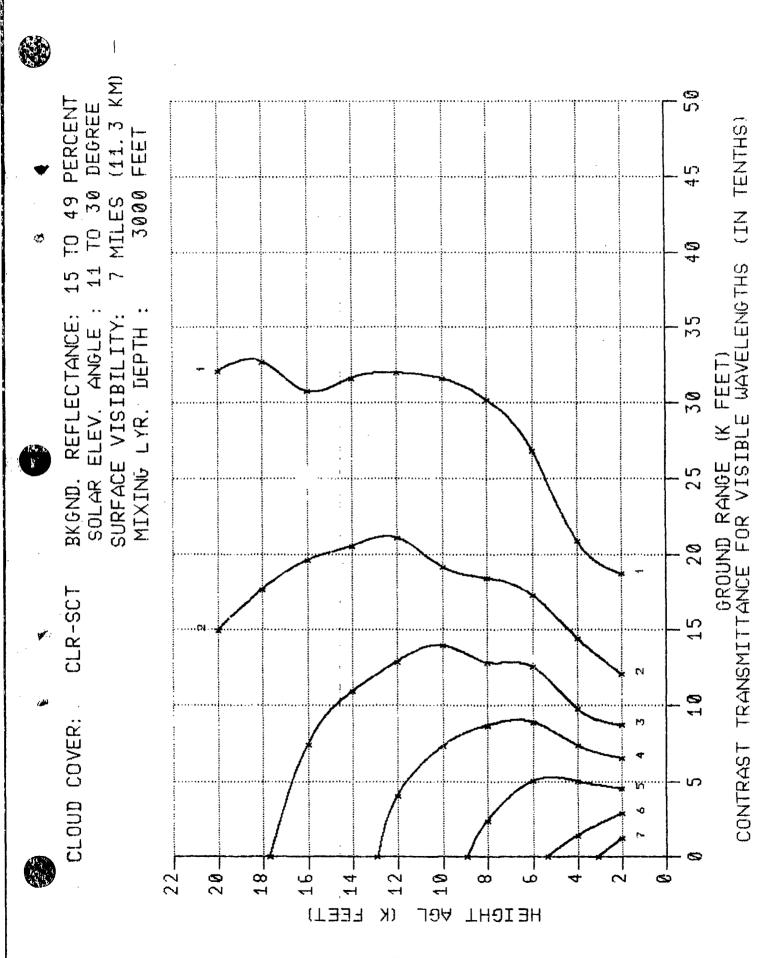
CLR-SCT

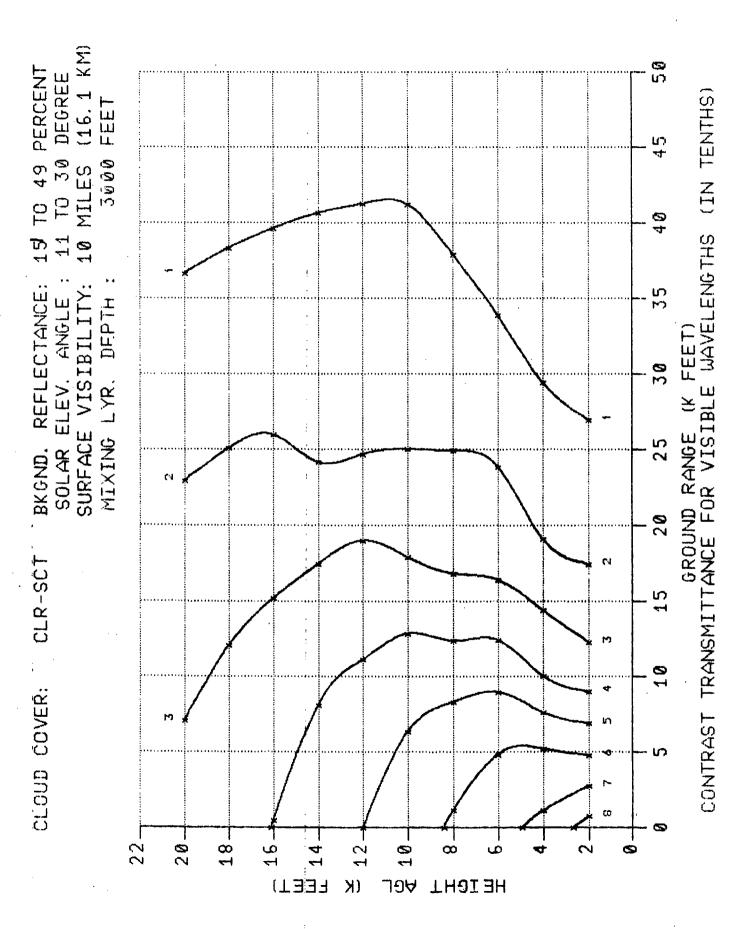
CLOUD COVER:

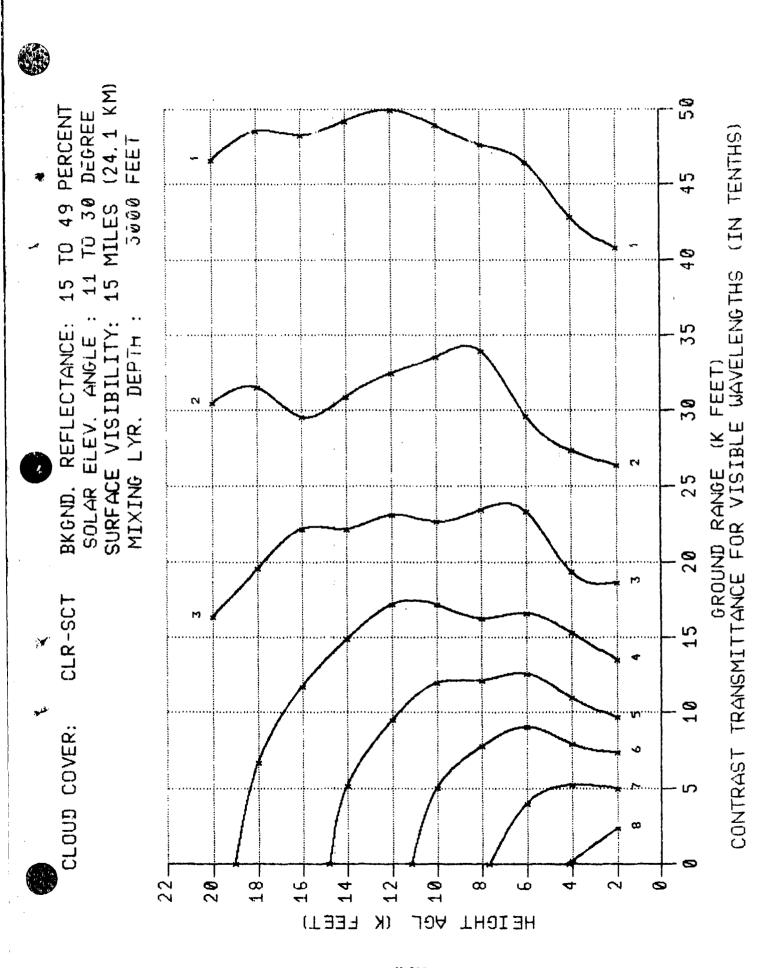


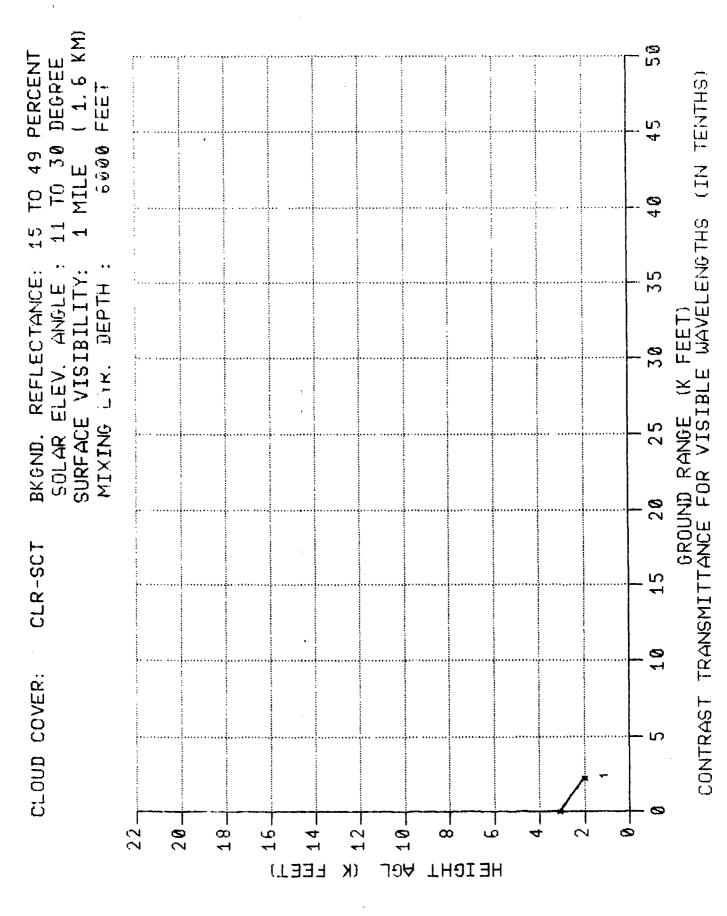




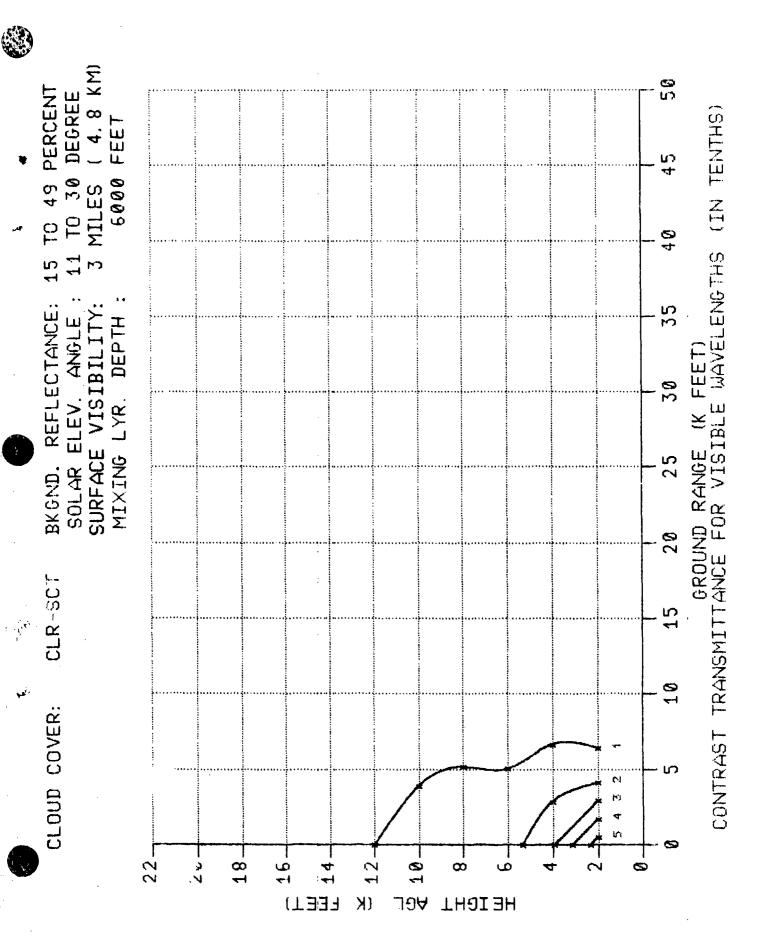


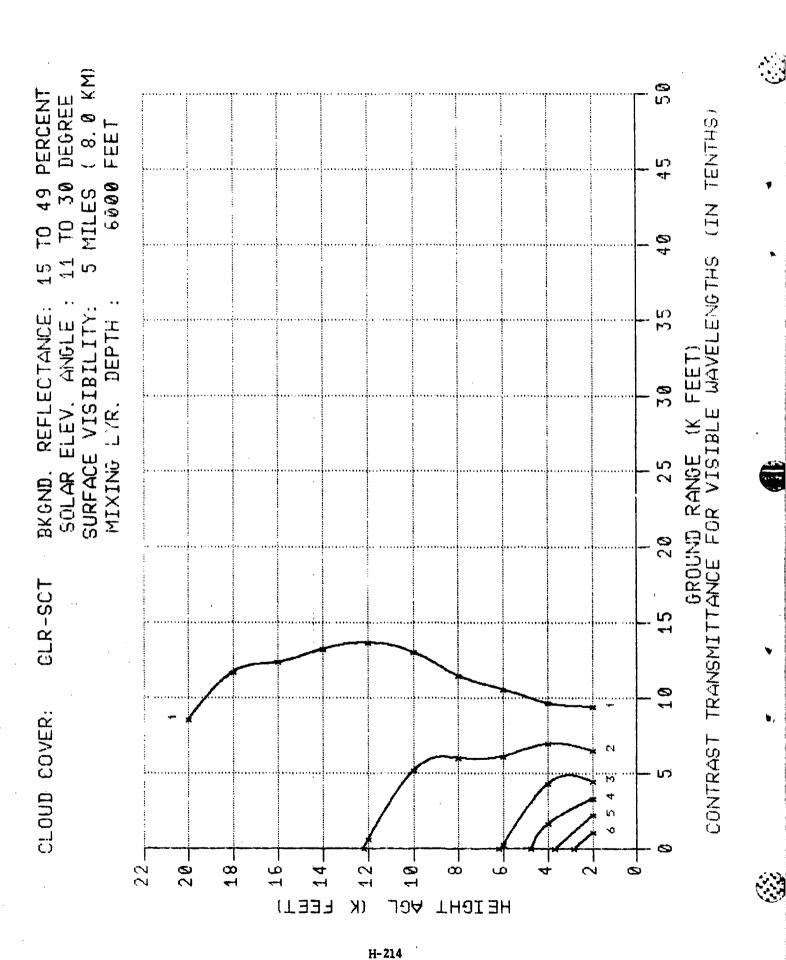


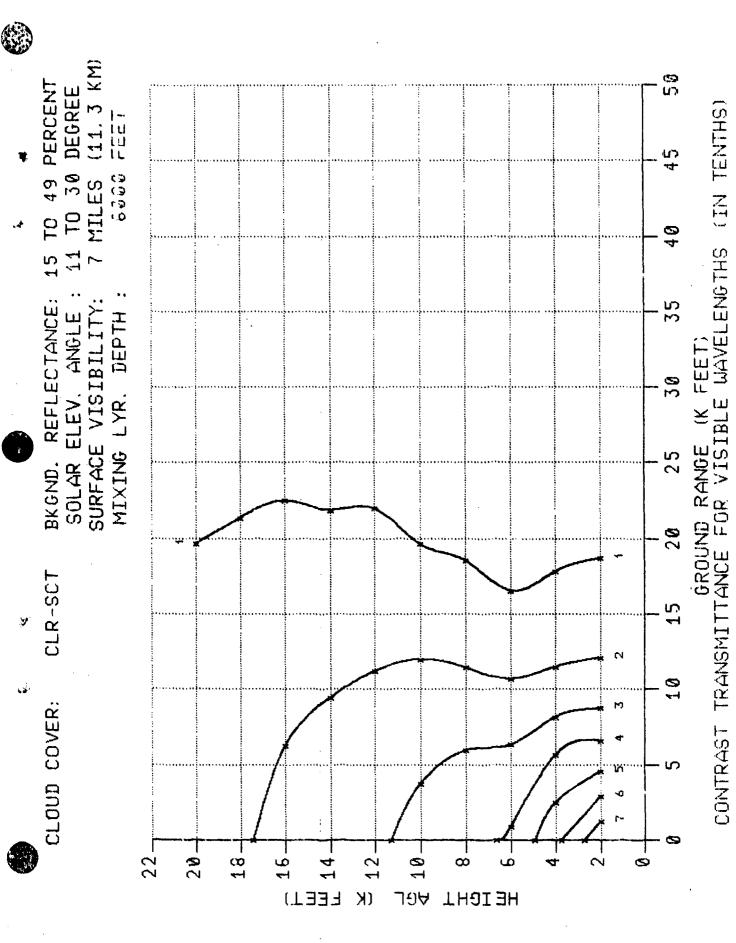




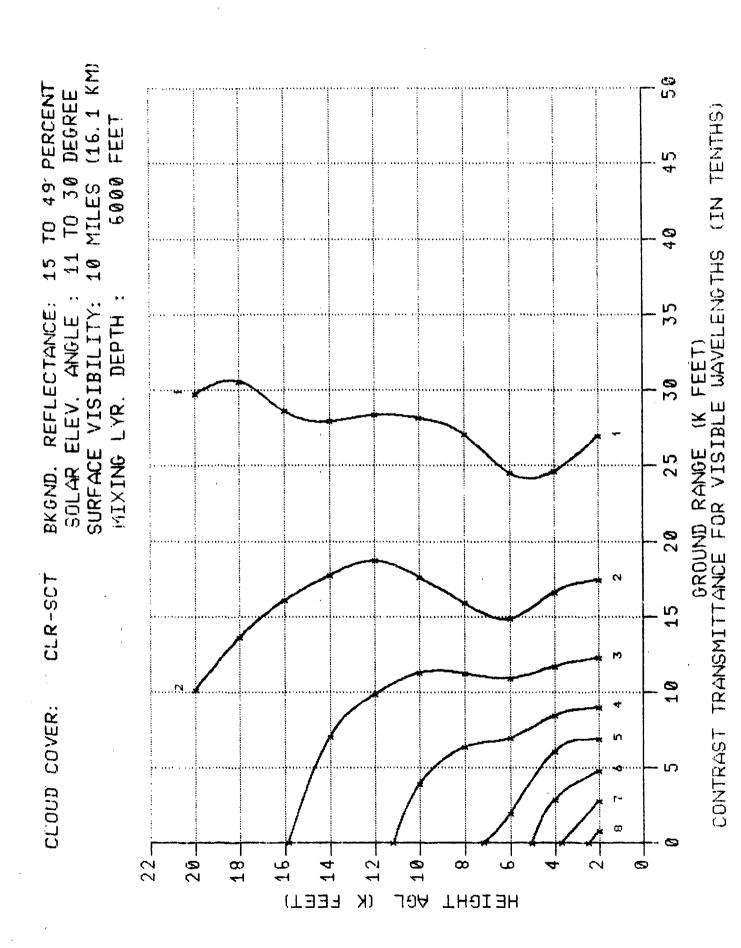
H-212

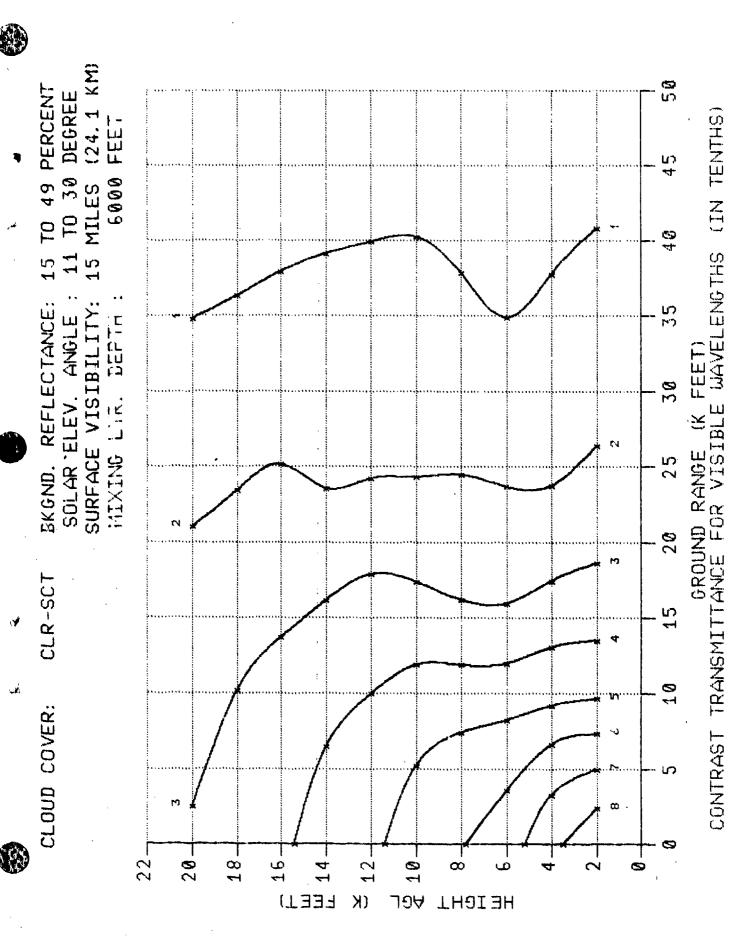




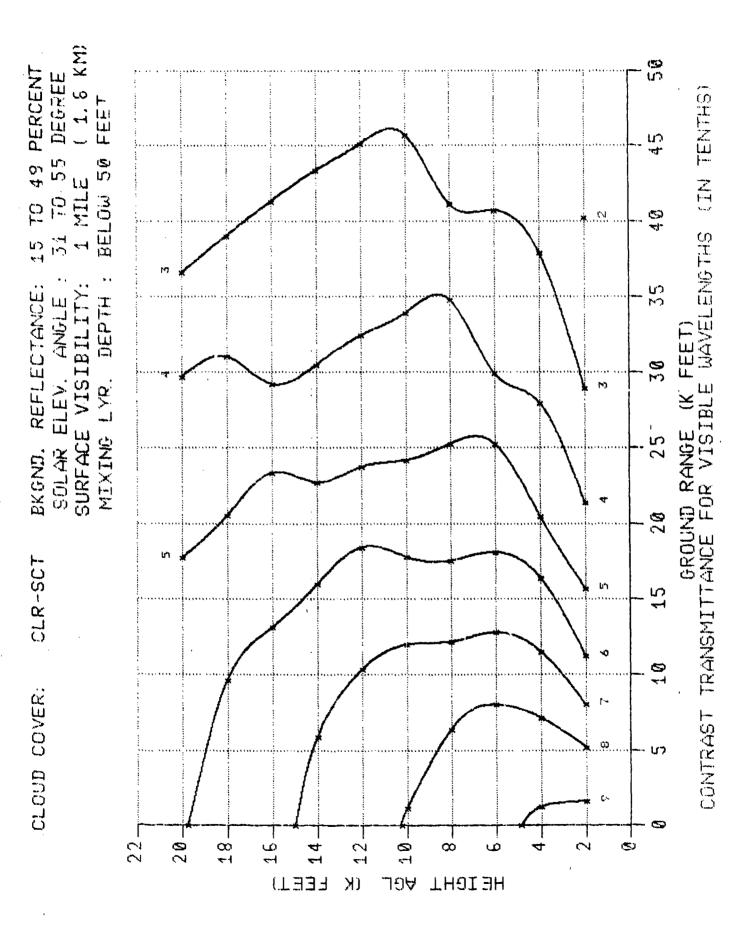


H-215





H-217

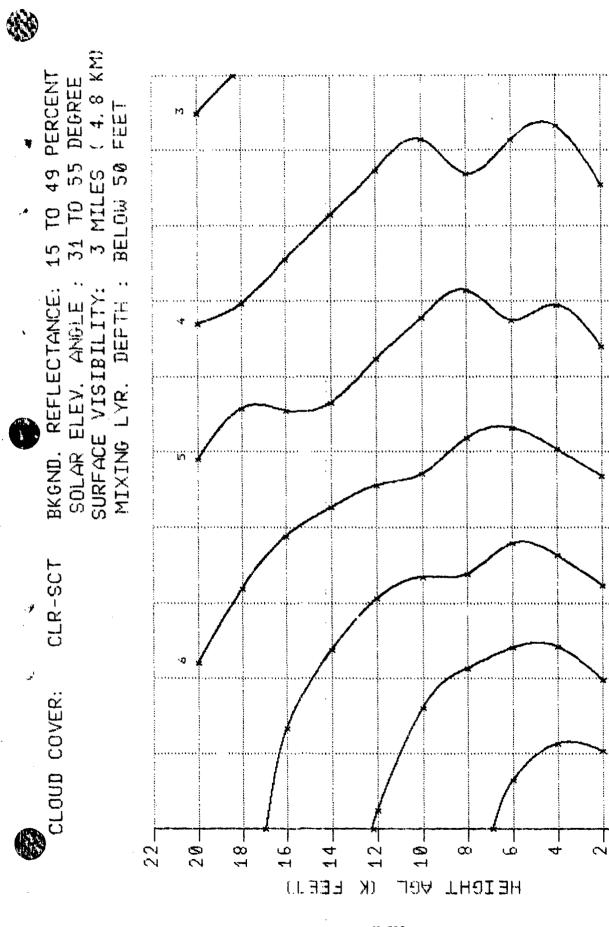


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PRODUCED TRANSPORT SOLLINGS

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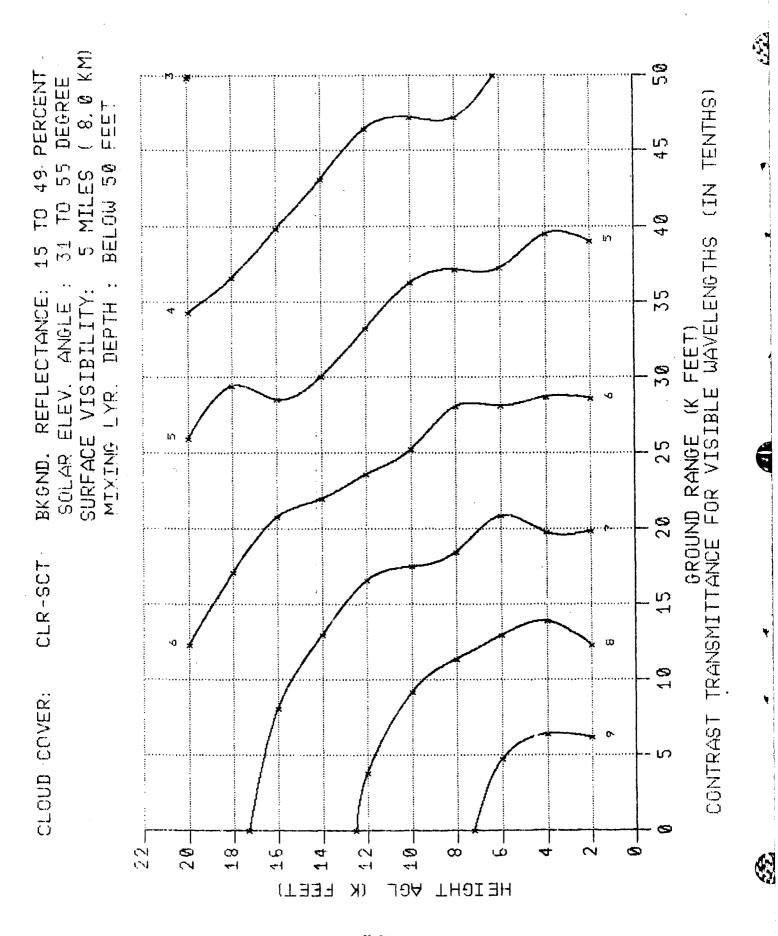
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GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

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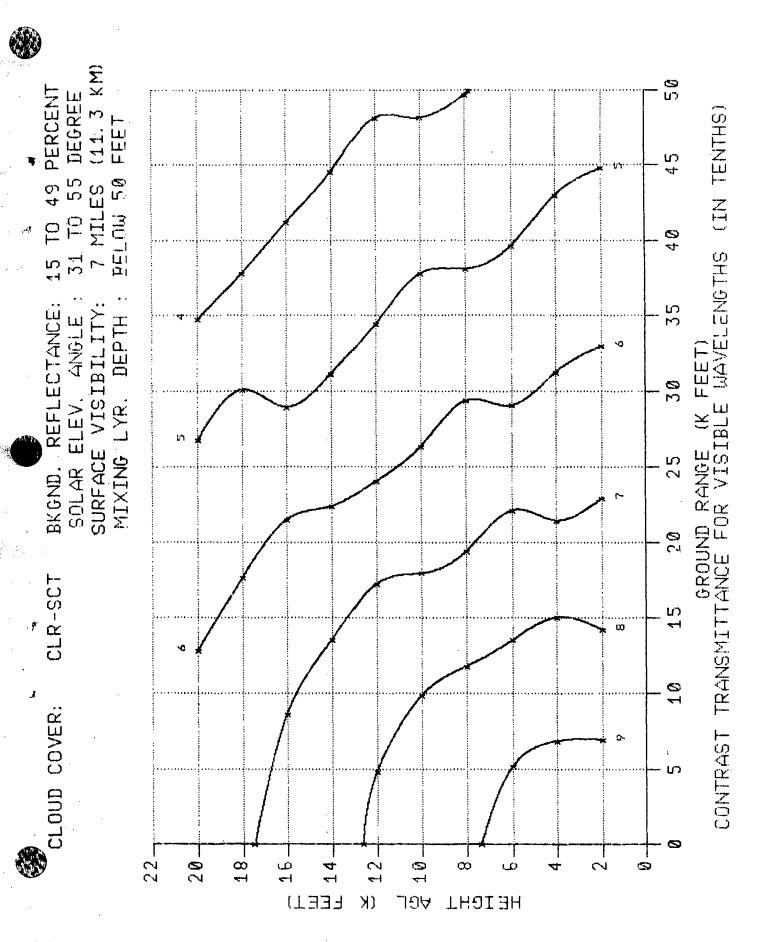
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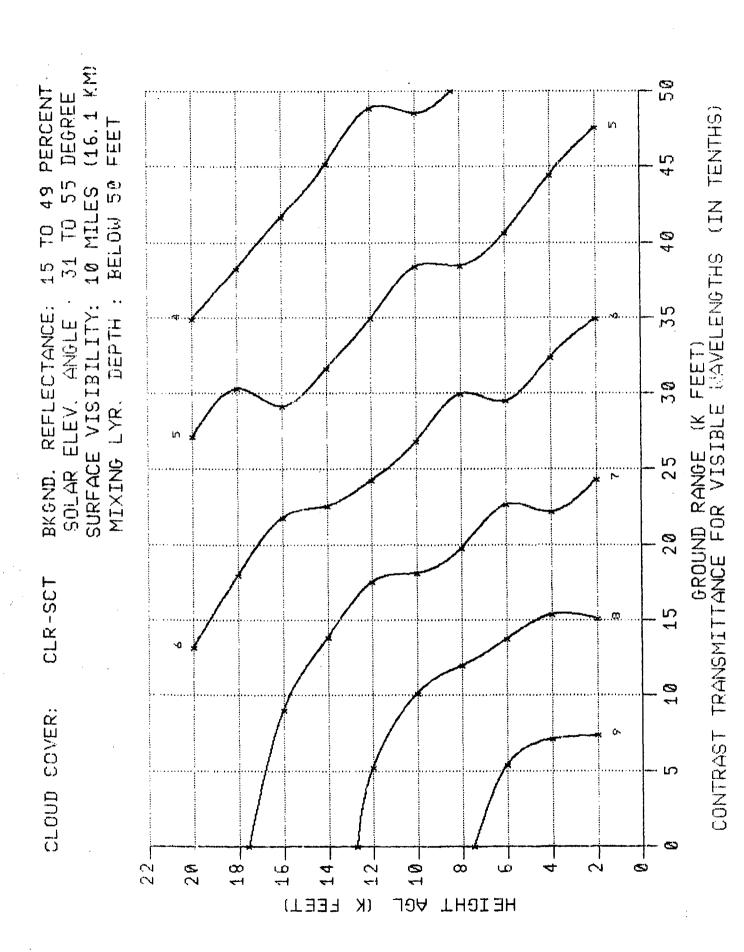


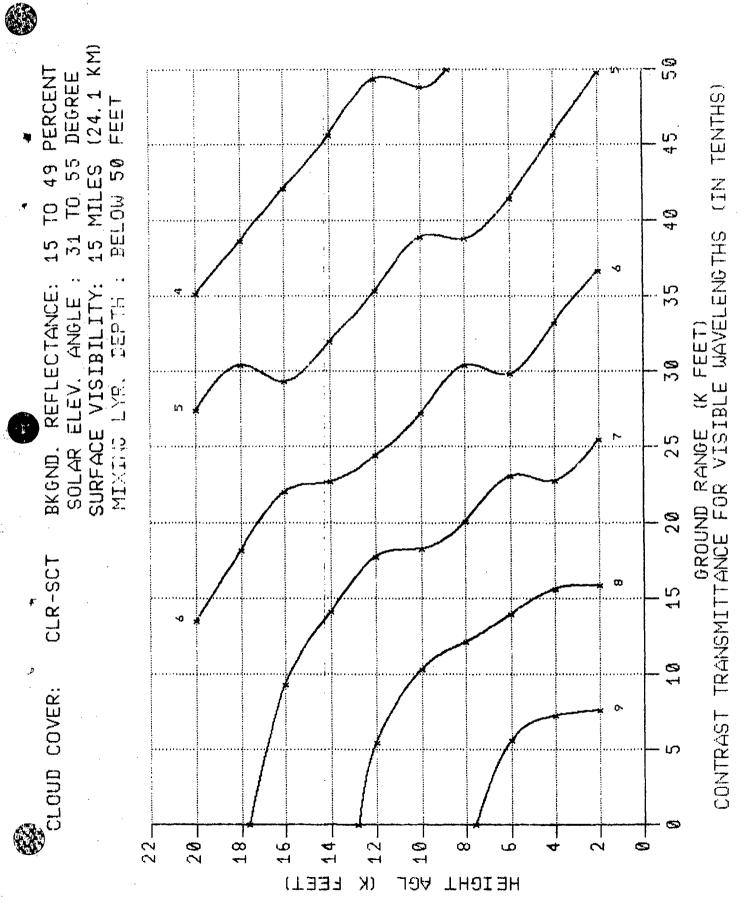
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H-220

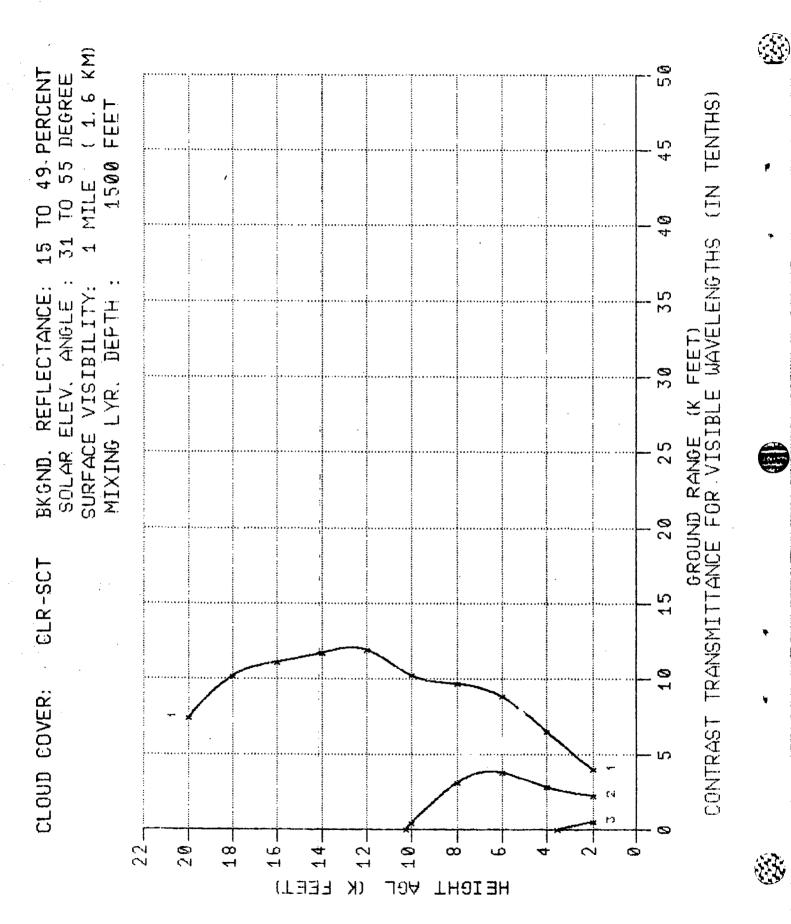


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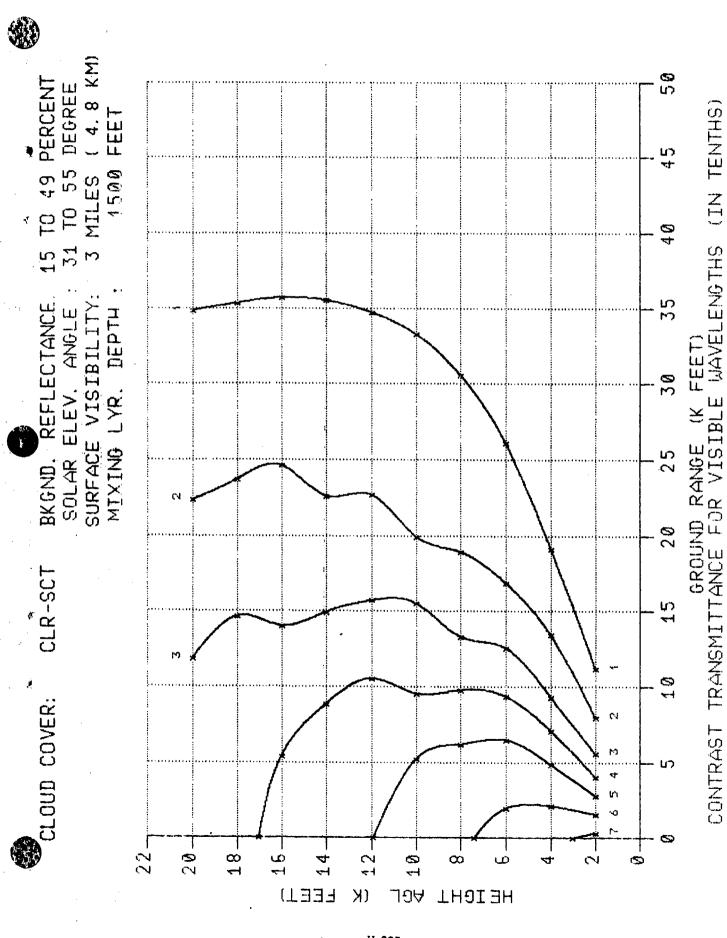




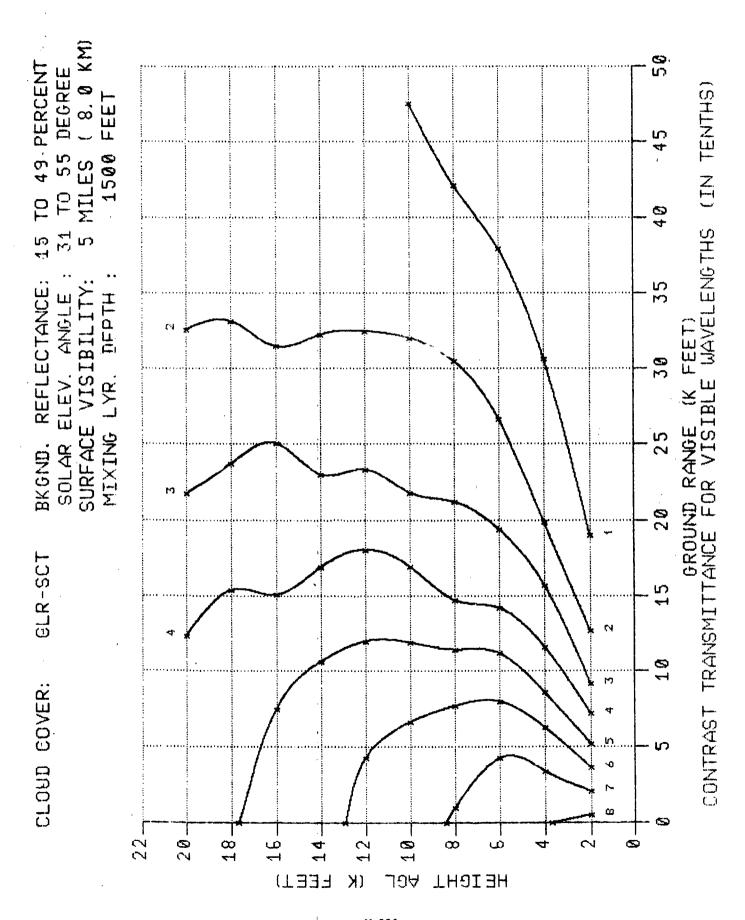
H-223



H-224



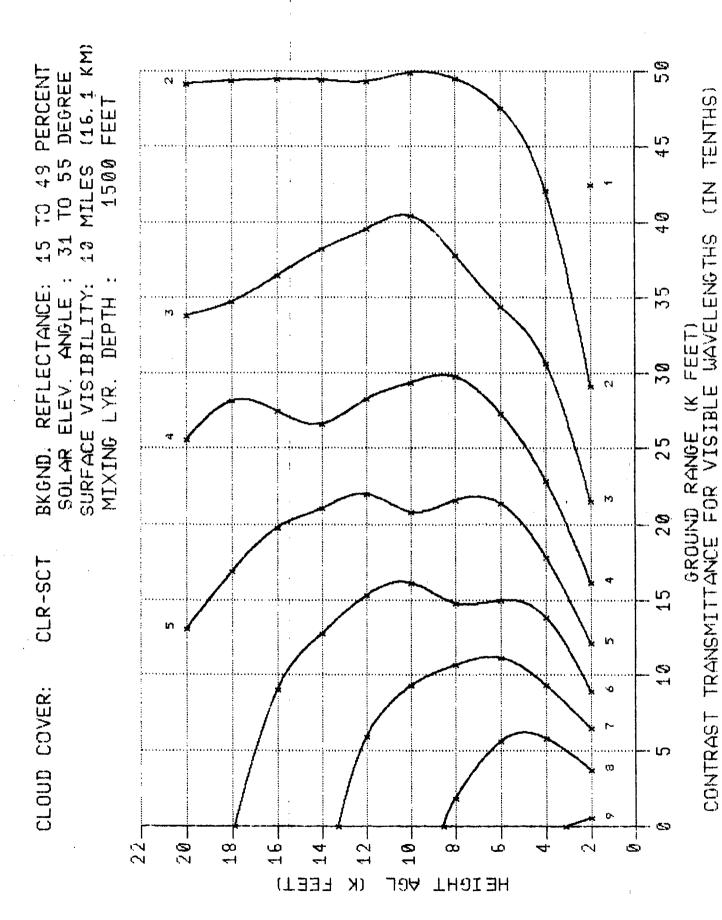
H-225



H-226

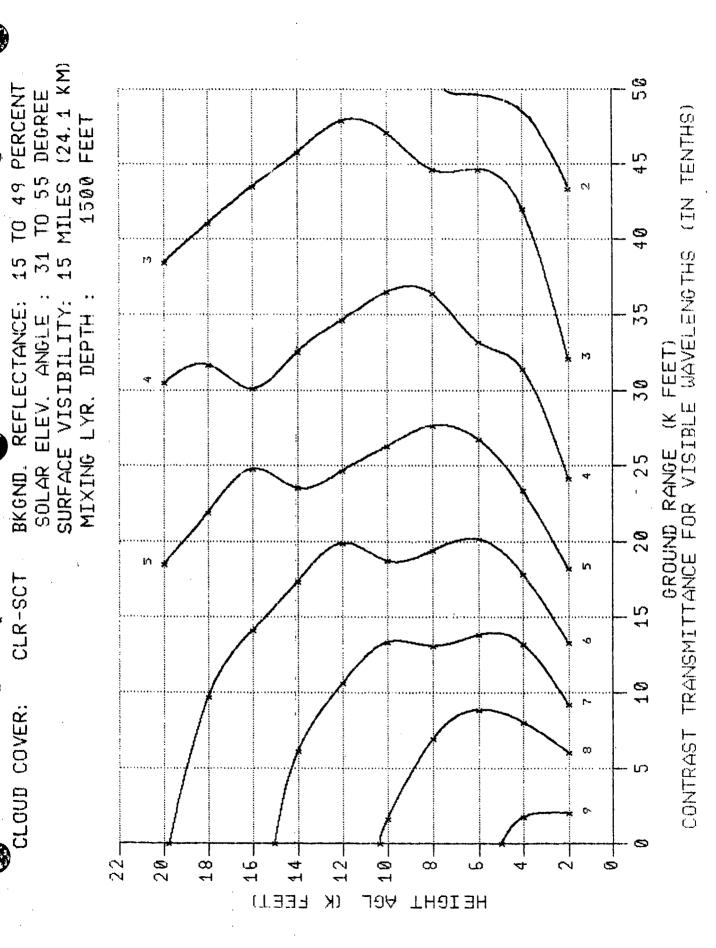
(11, 3 KM) (C) 49 PERCENT DEGREE 1500 7 MILES REFLECTANCE: SURFACE VISIBILITY: 35 ANGLE DEPTH 36 SOLAR ELEV. MIXING LYR. BKGND. 23 CLR-SCT 5 CLOUD COVER: 20-18 2 (25)  $\frac{1}{2}$ 9 10 **LEEL**) (K JOA HEICHL

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

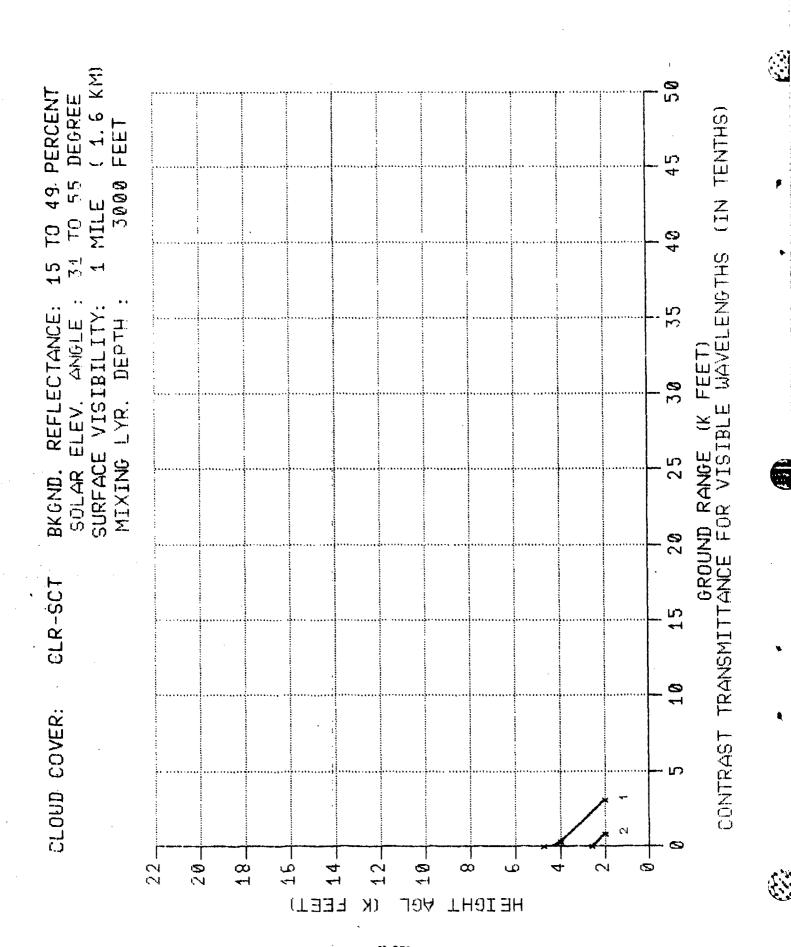


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H-229



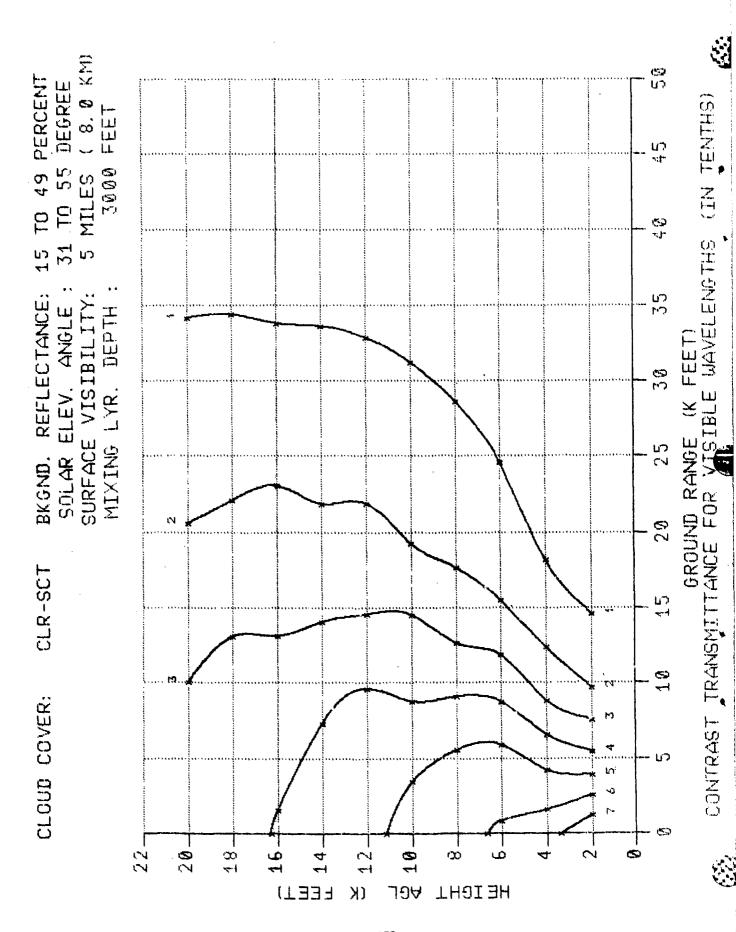
15 TO 49 PERCENT

CLR-SCT

CLOUD COVER:

TO 55 DEGREE

H-231

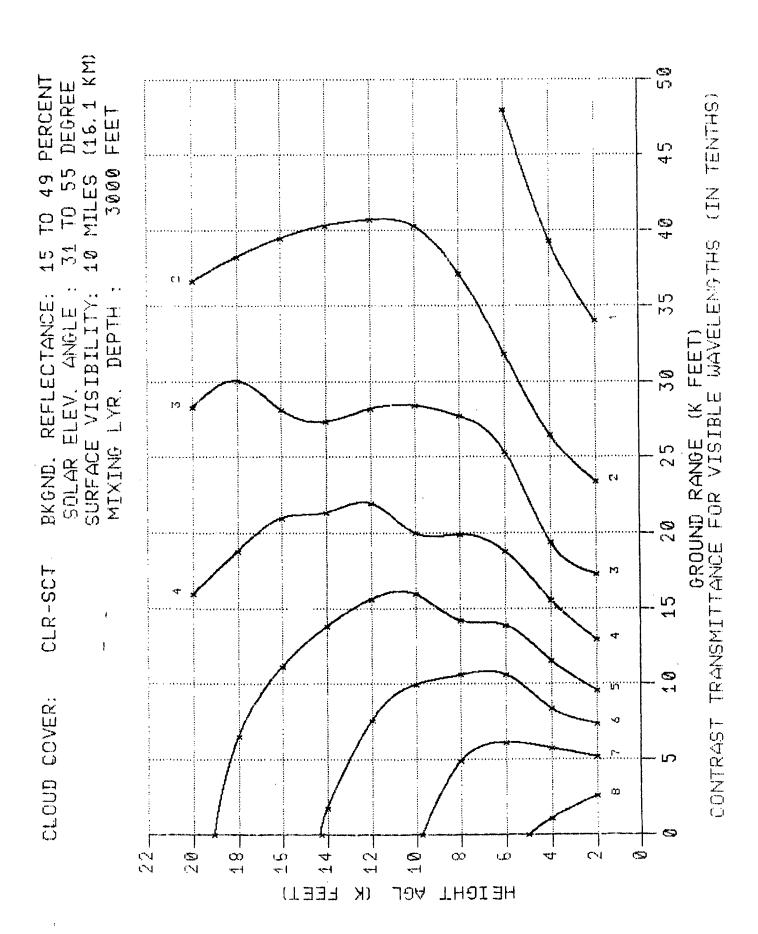


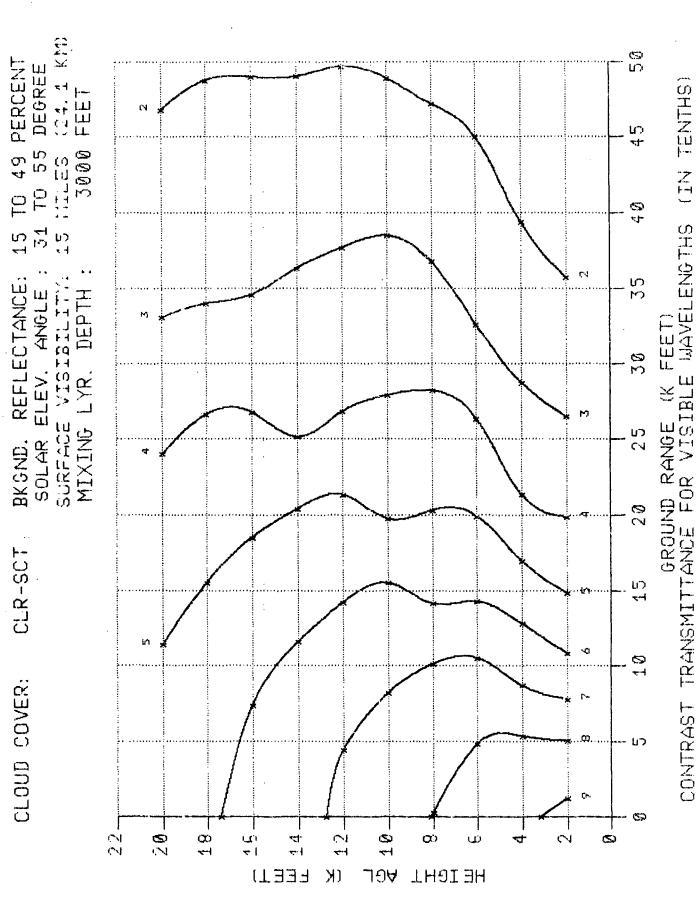
(11, 3 KM) 50 TO 49 PERCENT DEGREE GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) U) 3000 **TO 55** 7 MILES MIXING LYR. DEPTH : REFLECTANCE: SURFACE VISIBILITY: 77 77 BKGND, REFLECTANCE SOLAR ELEV. ANGLE (S) 20 CLR-SCT 15 CLOUD COVER: 22  $18_{-}$ 20-10-(Z) 14-12-2 (E)  $\infty$ ۾ LEELI ίK

H-233

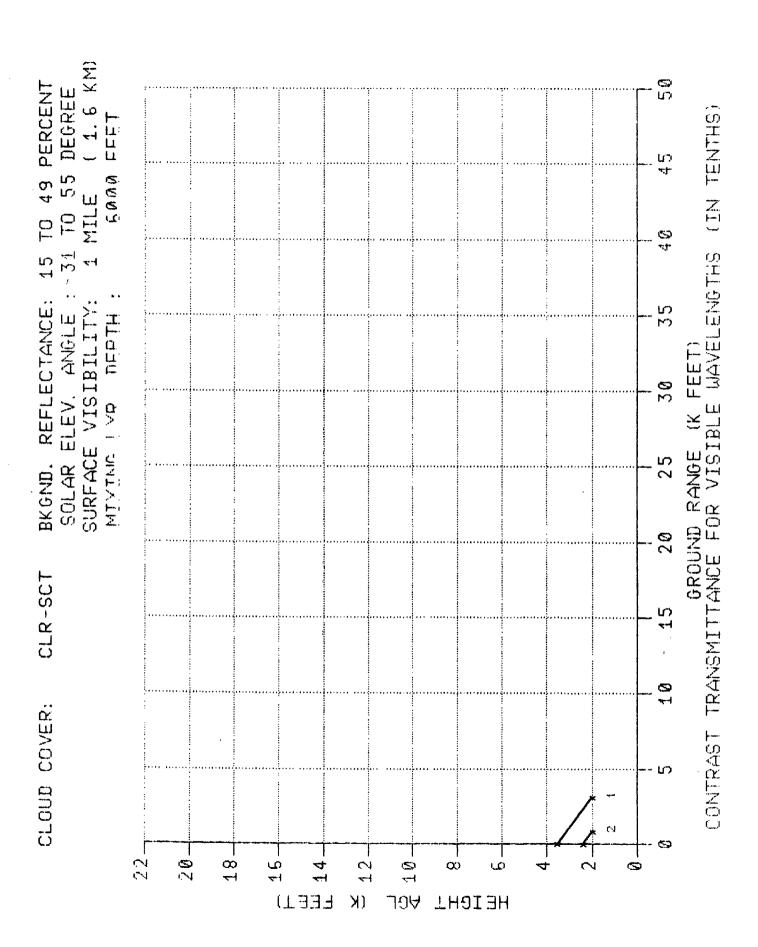
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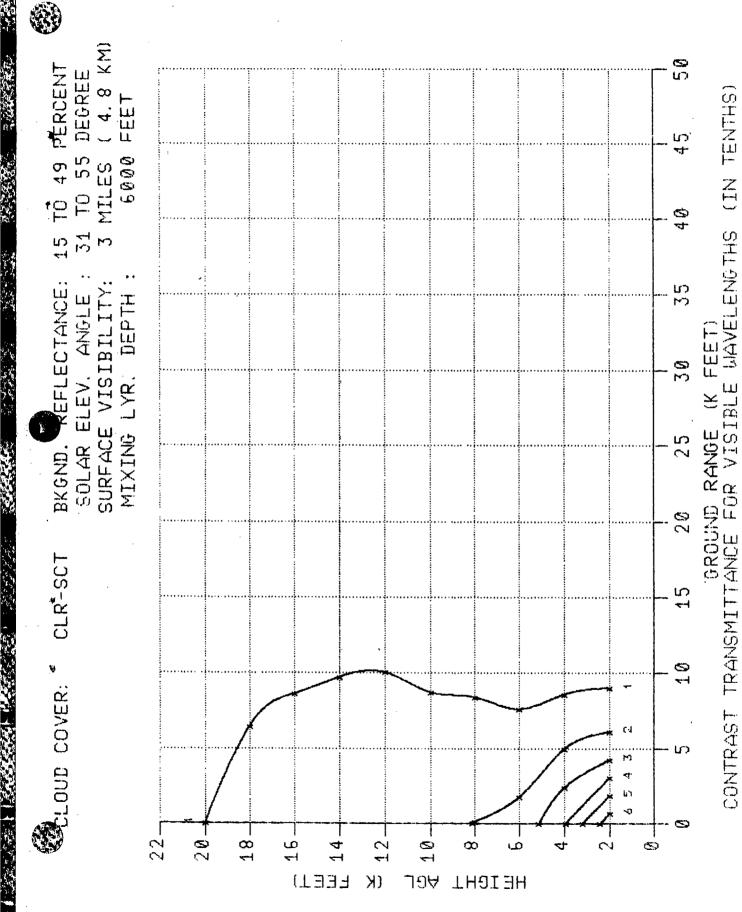




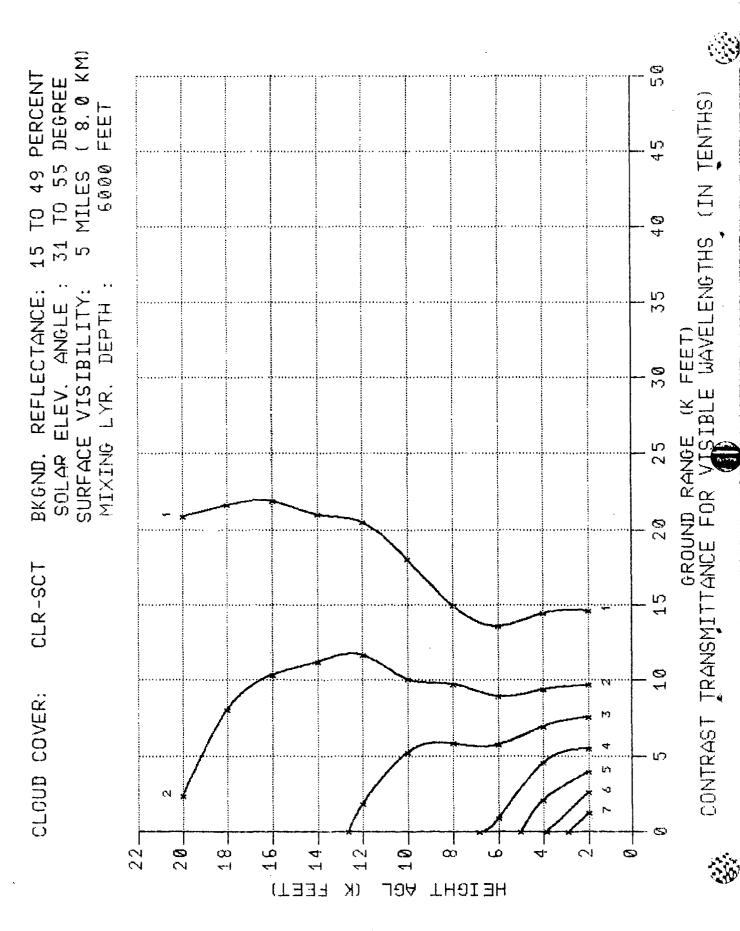
H-235

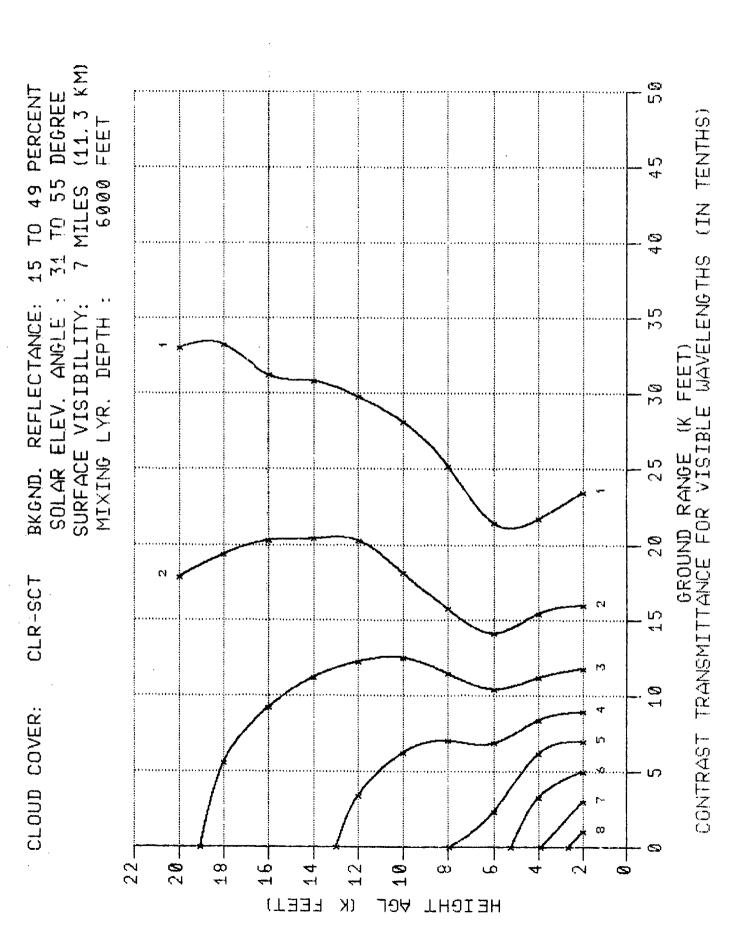


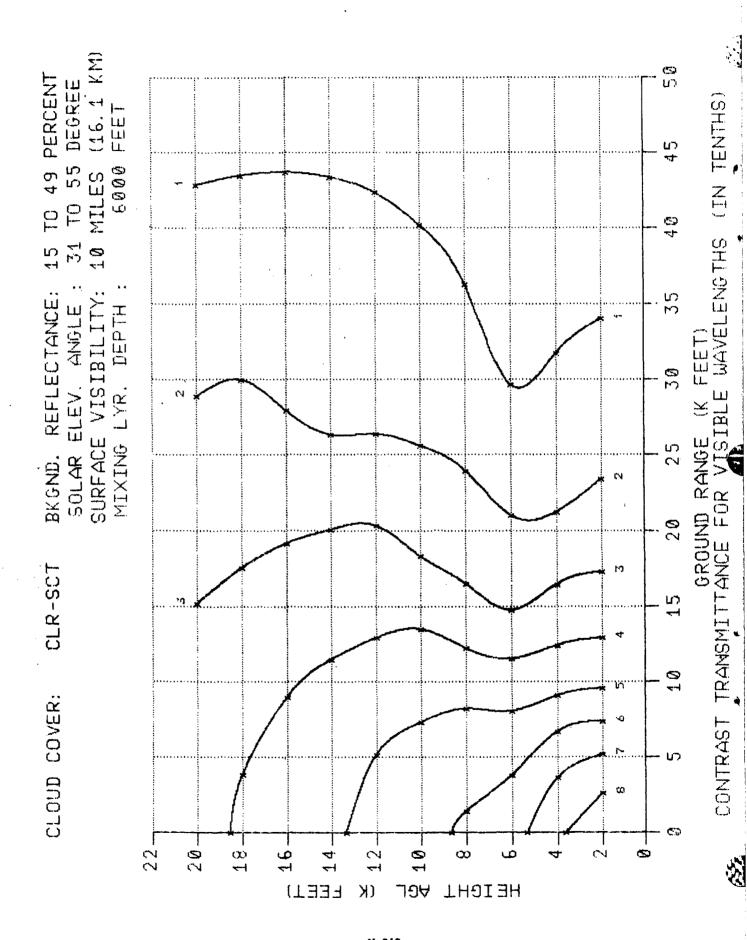
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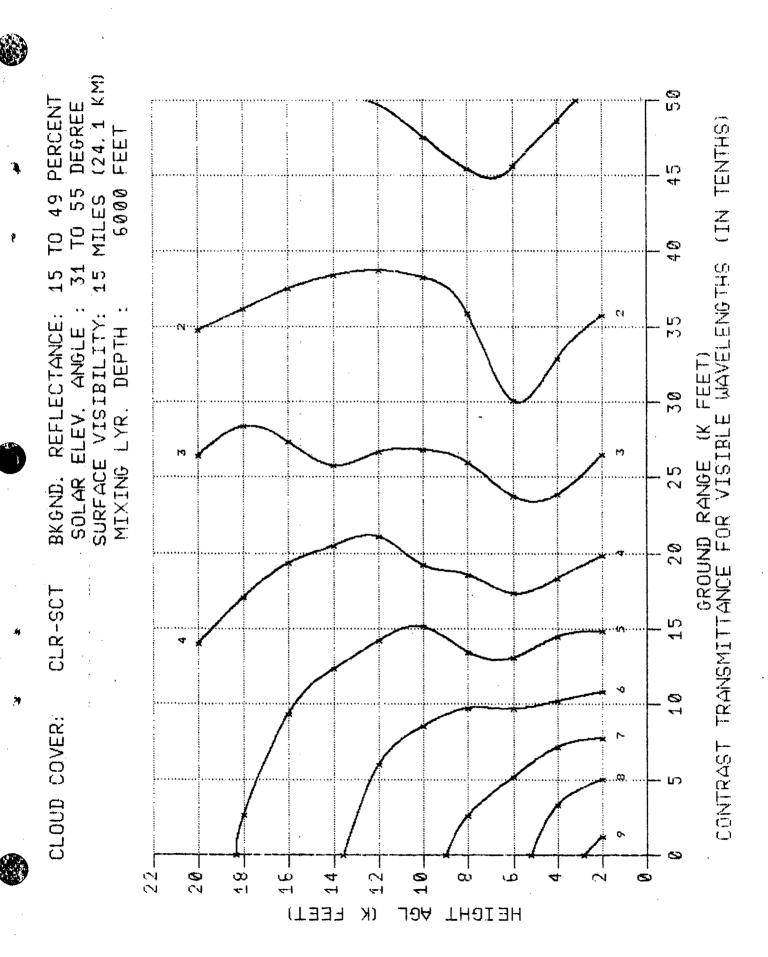
H-237

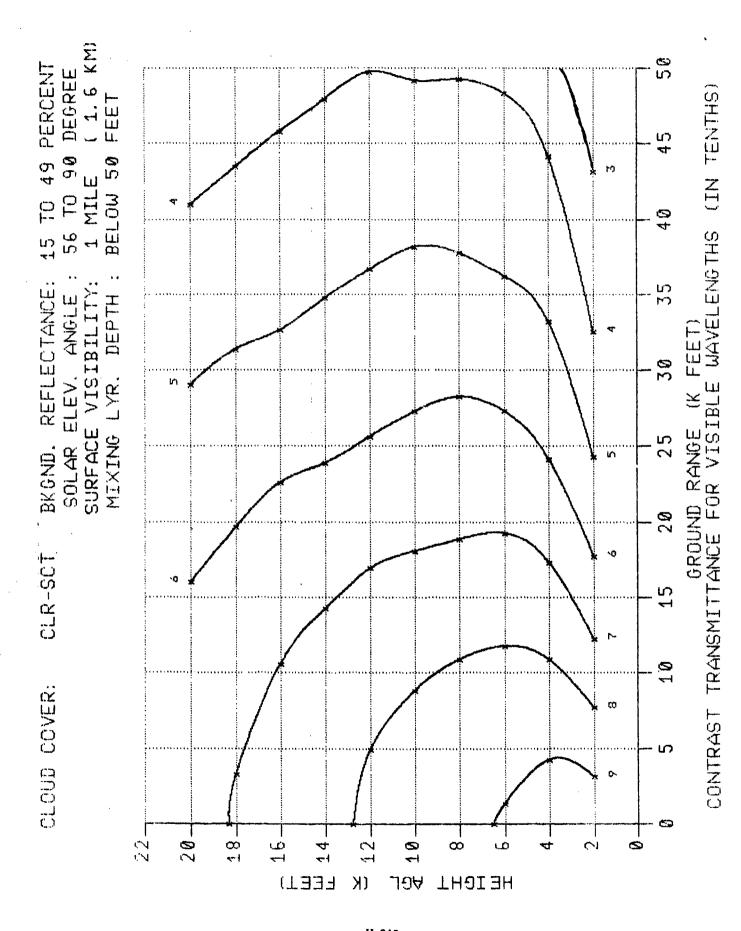






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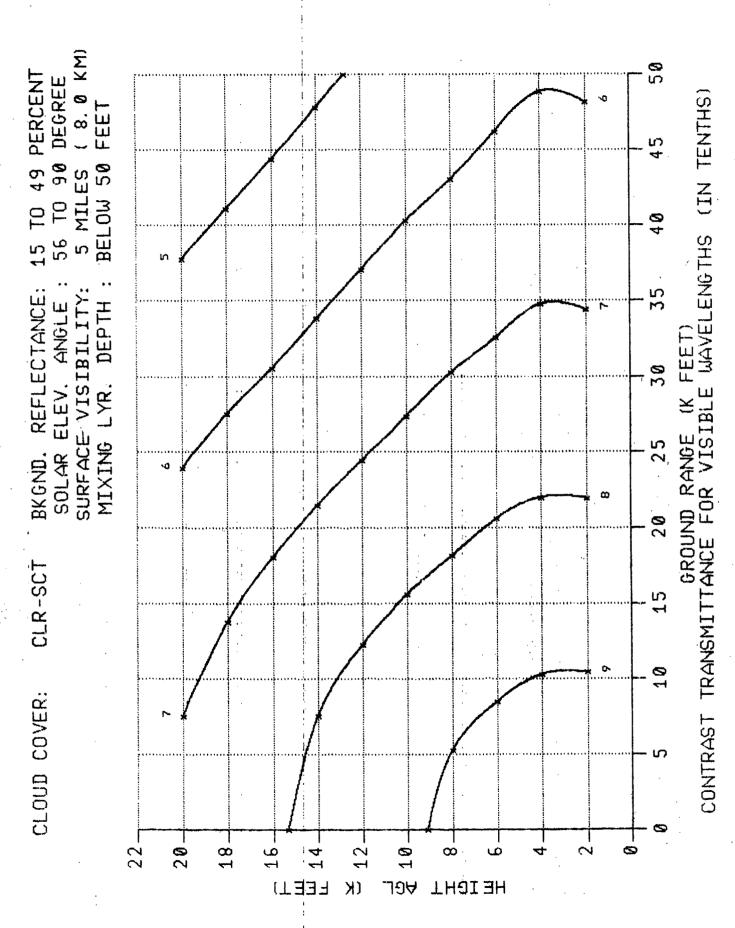


H-242

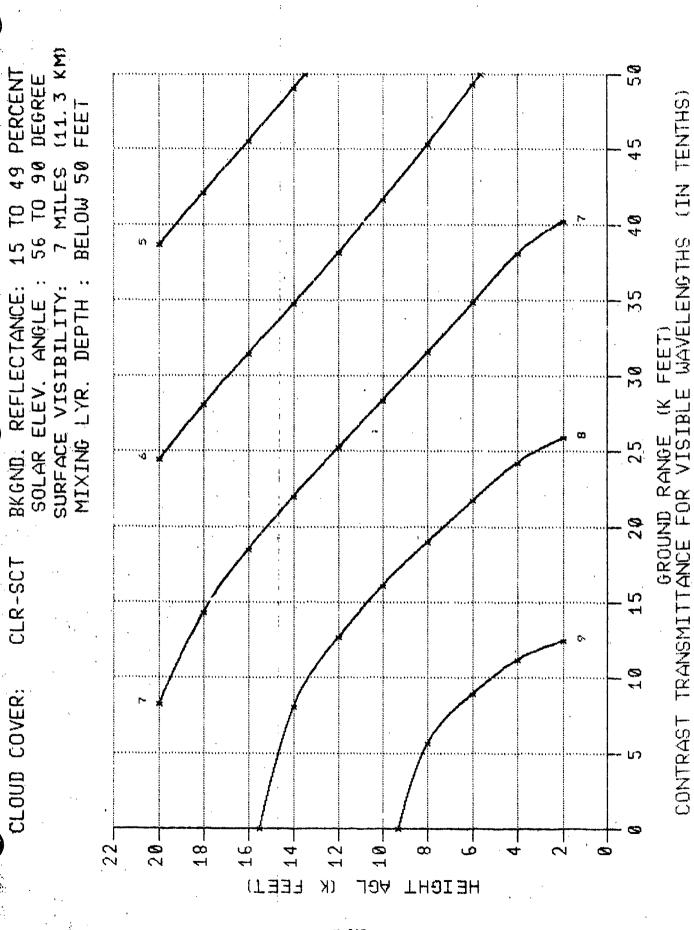
( 4, 8 KM) 56 TO 90 DEGREE 3 MILES (4.8 KM BELOW 50 FEET 50 15 TO 49 PERCENT BKGND. REFLECTANCE: SOLAR ELEV. ANGLE: SURFACE VISIBILITY: MIXING LYR. DEPTH: 3 30 . 25 20 CLR-SCT 15 CLOUD COVER: 12-10 8 2 16-18 ပ် 20. (TEET) JÐA ίK HE ICHT

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

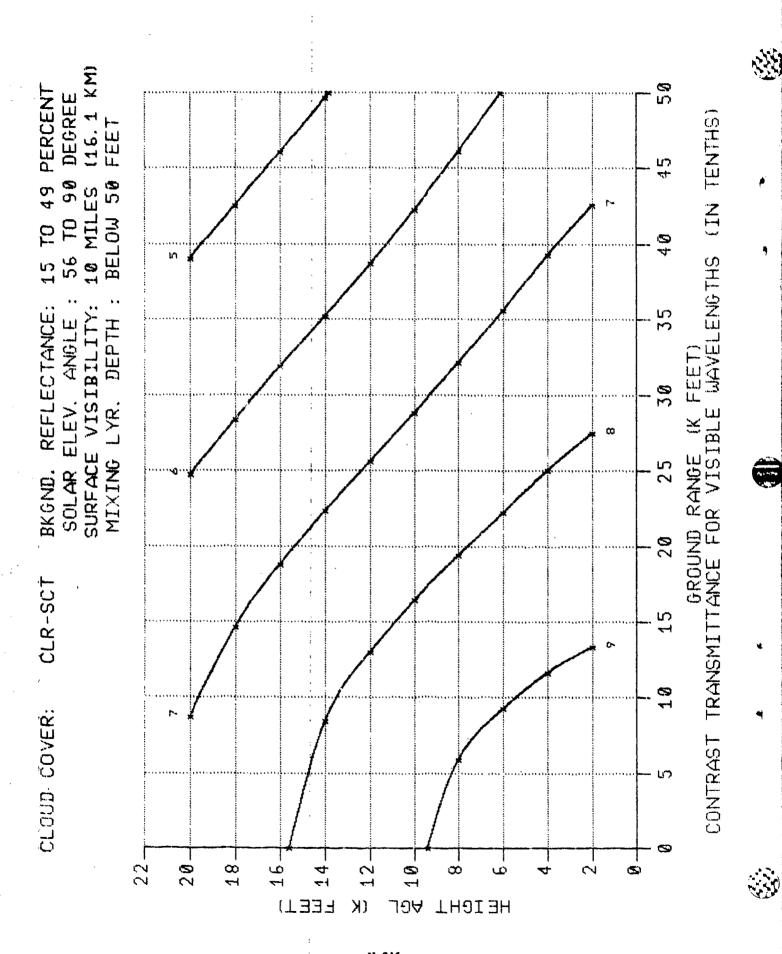
H-243

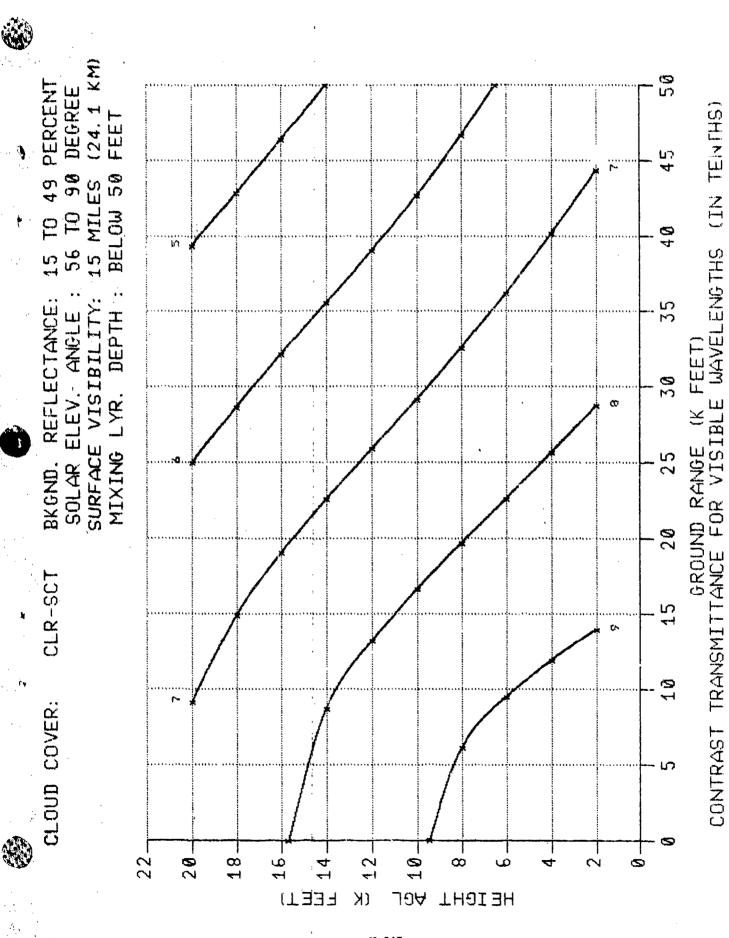


H-244

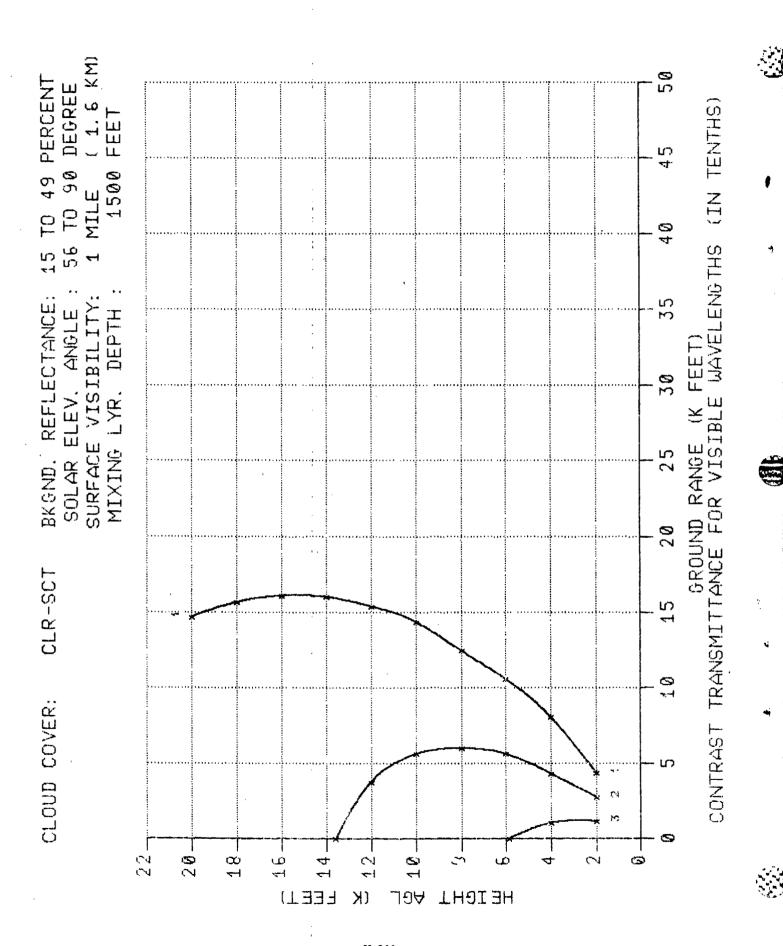


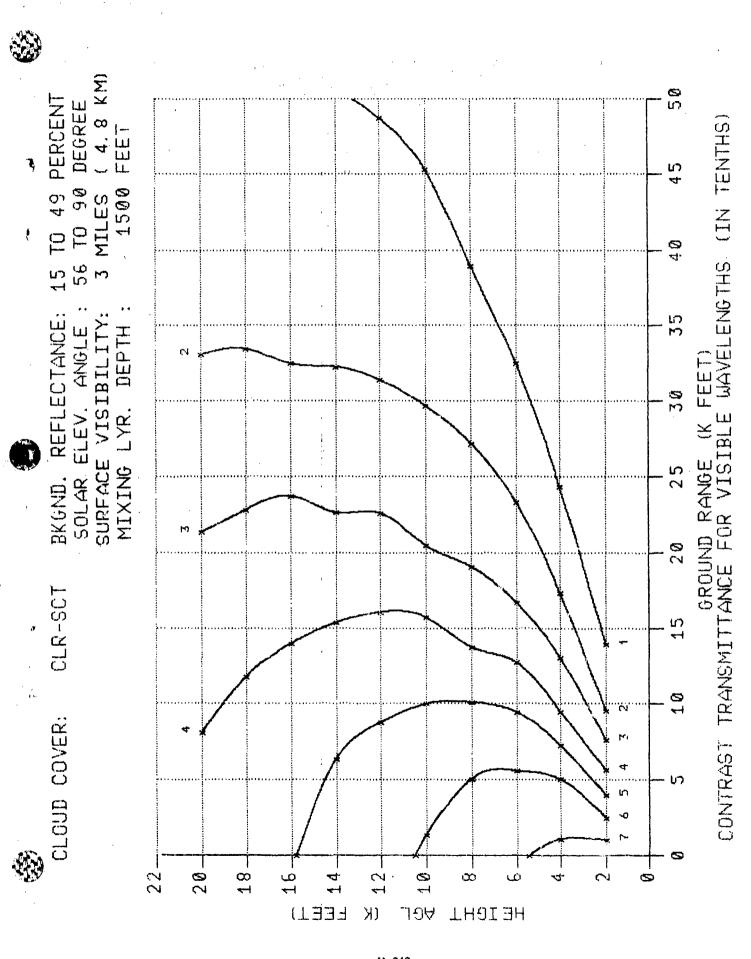
H-245



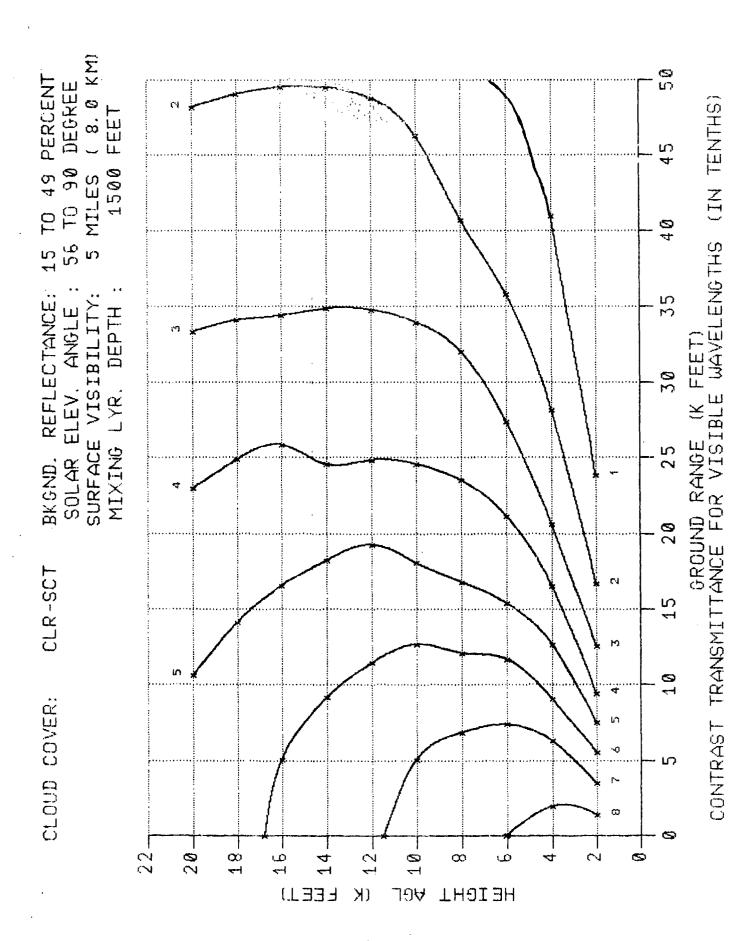


H-24





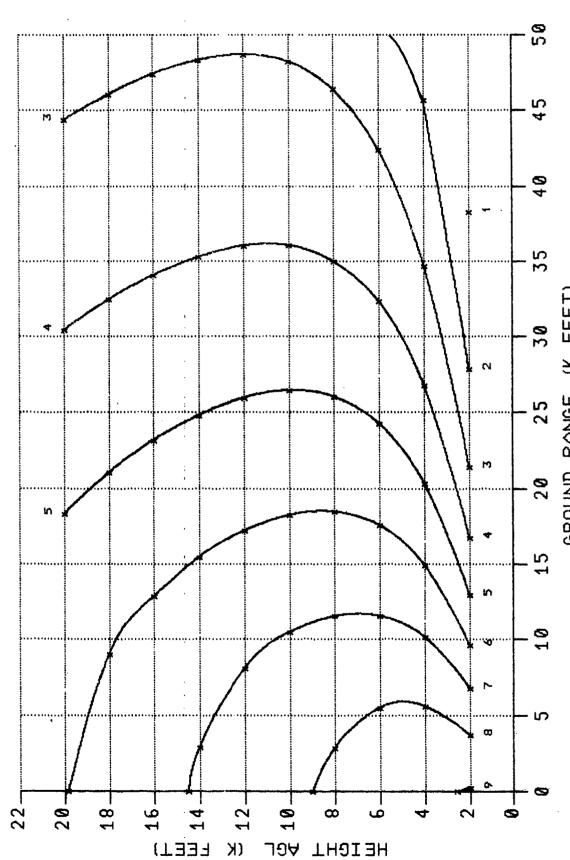
H-249



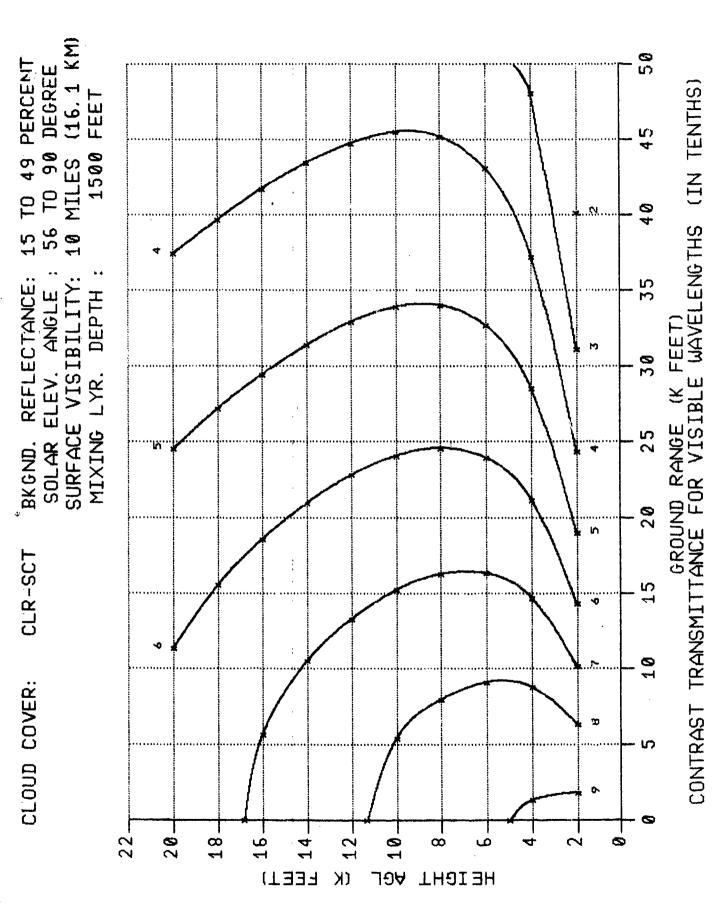
15 TO 49 PERCENT BKGND. REFLECTANCE: CLR-SCT CLOUD COVER:

SOLAR ELEV. ANGLE : SURFACE VISIBILITY: MIXING LYR. DEPTH:

56 TO 90 DEGREE 7 MILES (11.3 KM) 1500



GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)



56 TO 90 DEGREE 15 MILES (24.1 KM) 50 15 TO 49 PERCENT FEET 45 1500 40 REFLECTANCE: SOLAR ELEV. ANGLE SURFACE VISIBILITY: 35 MIXING LYR. DEPTH 30 BK GND. 20 CLR-SCT 15 10 CLOUD COVER: 22 -20-18-16-12-2 14-16-6

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

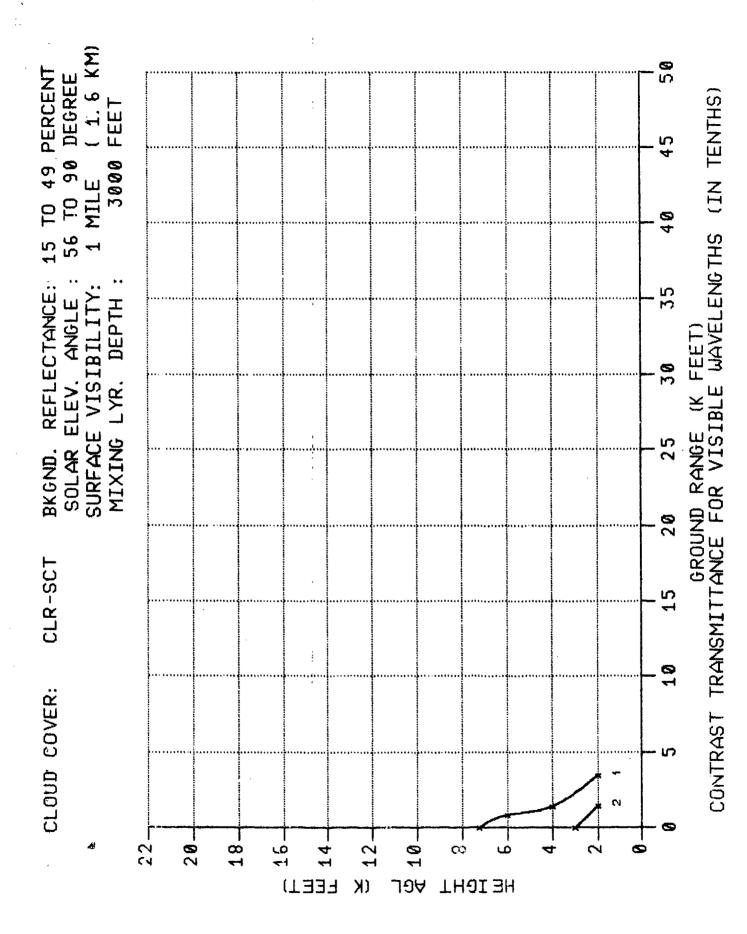
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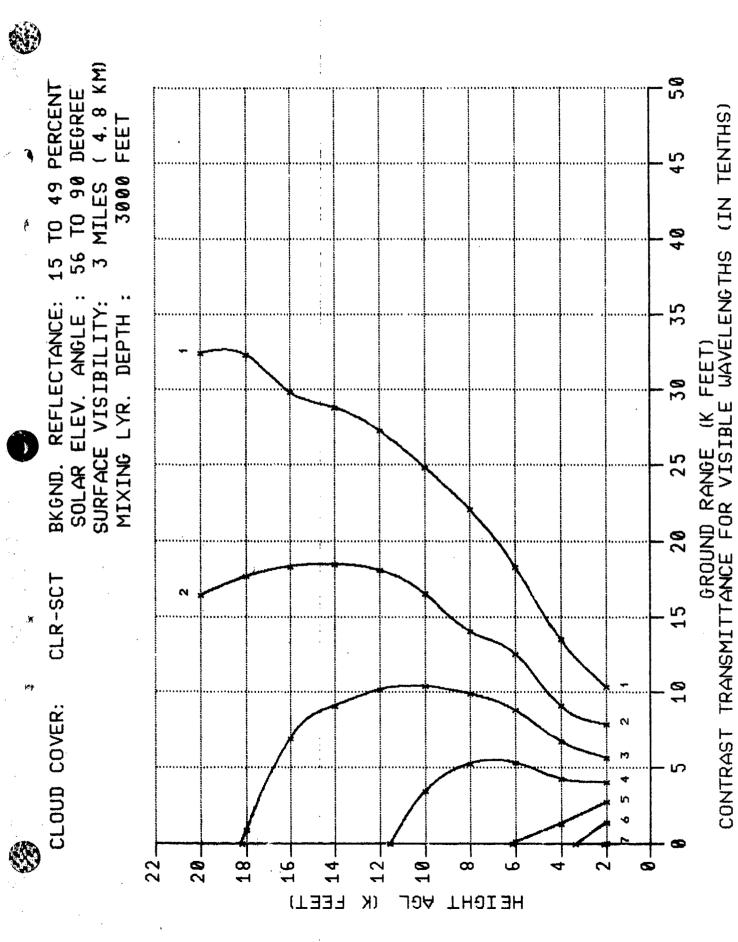
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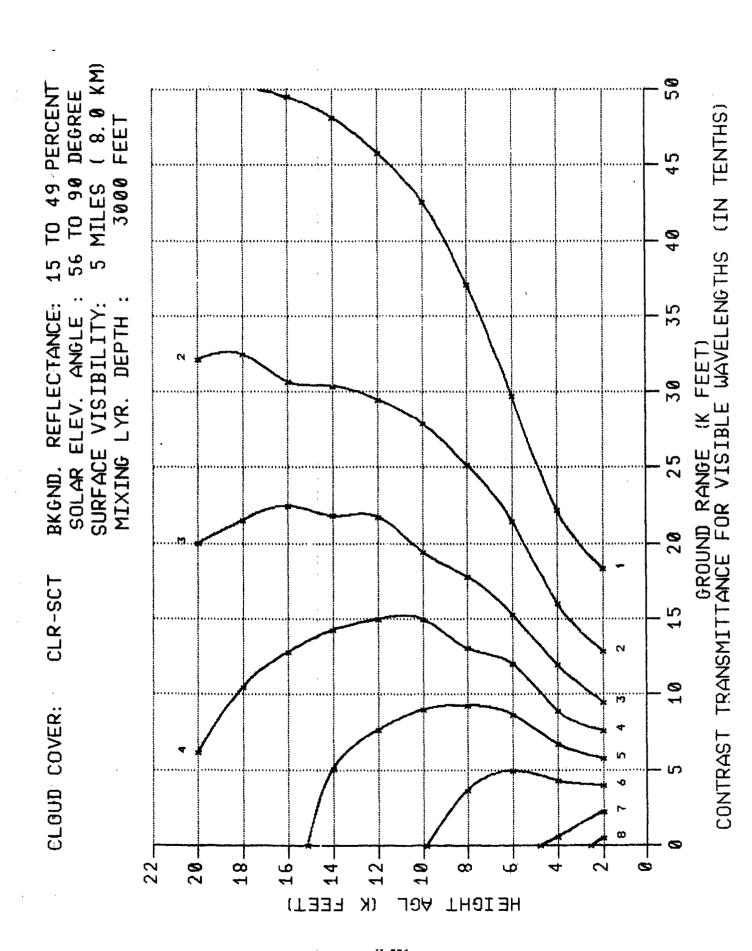
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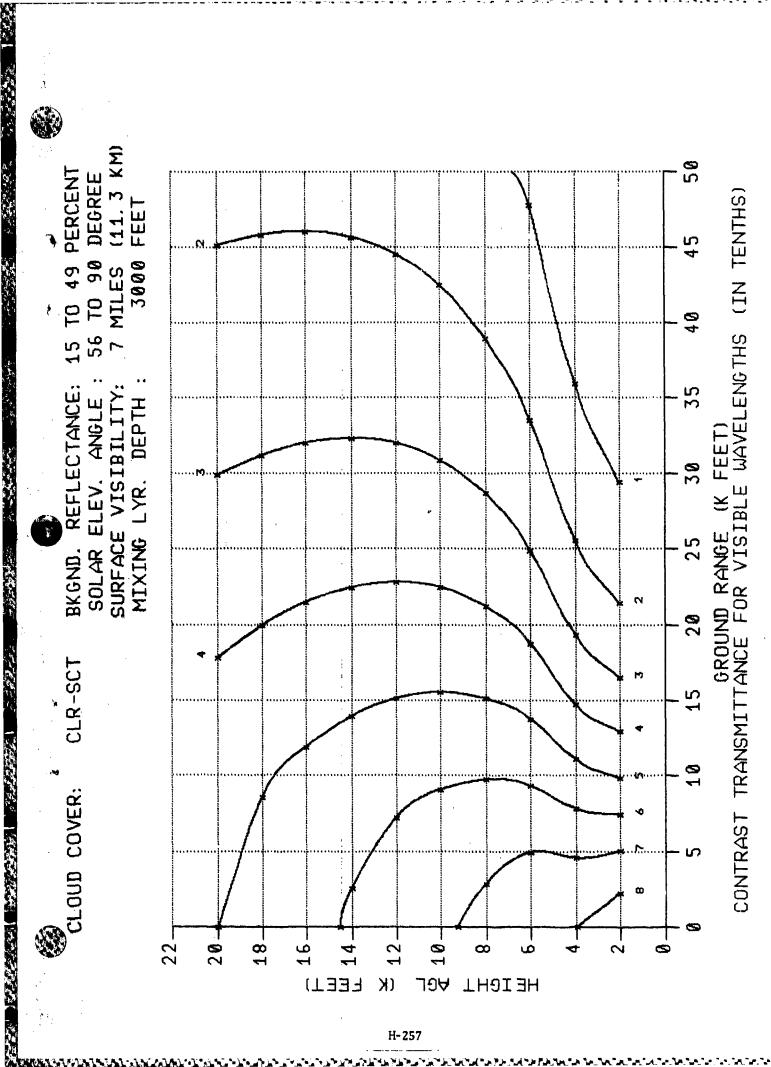


H-254

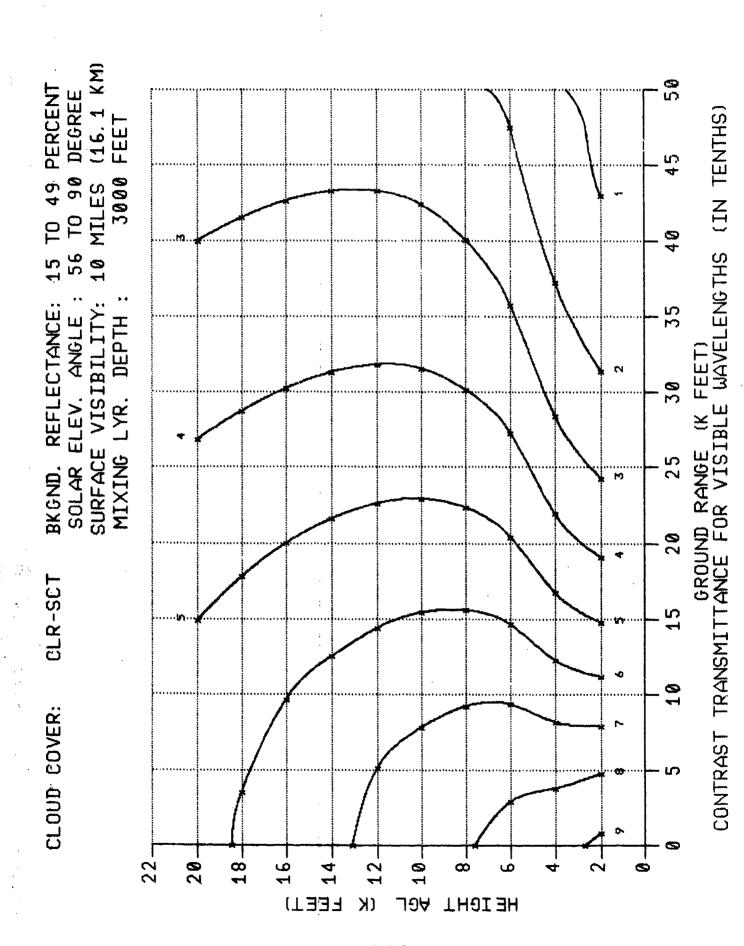


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GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) MIXING LYR. DEPTH: 'n 20 15 20-181 16 14- $12_{-}$ 10 ا ف 8 LEETI ίK JOA HEIGHL

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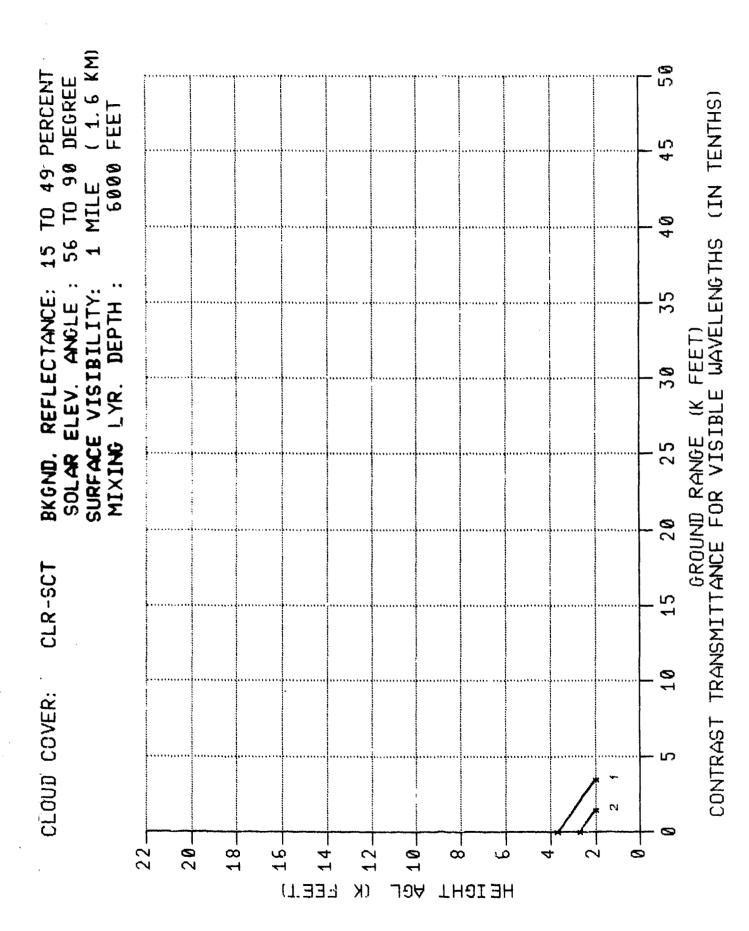
15 TO 49 PERCENT

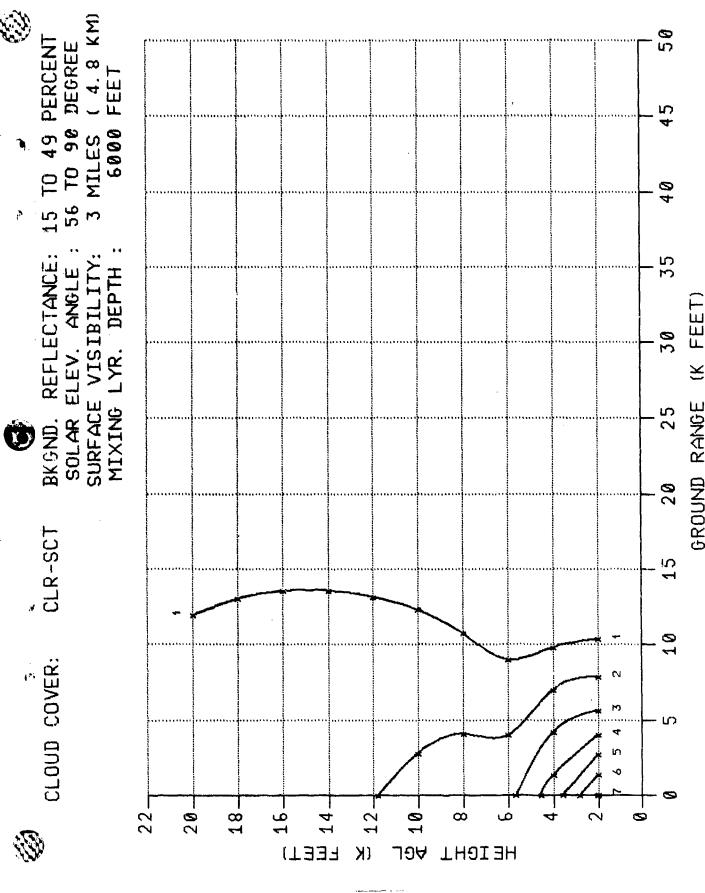
TO 90 DEGREE

BKGND. REFLECTANCE: SOLAR ELEV. ANGLE : SURFACE VISIBILITY:

CLR-SCT

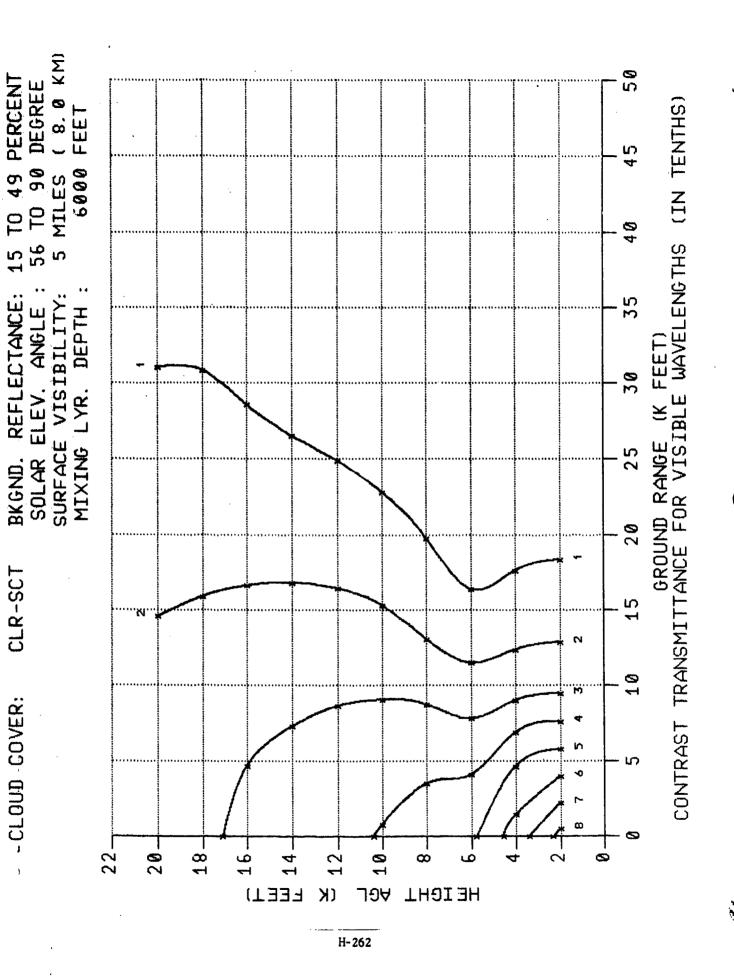
CLOUD COVER:

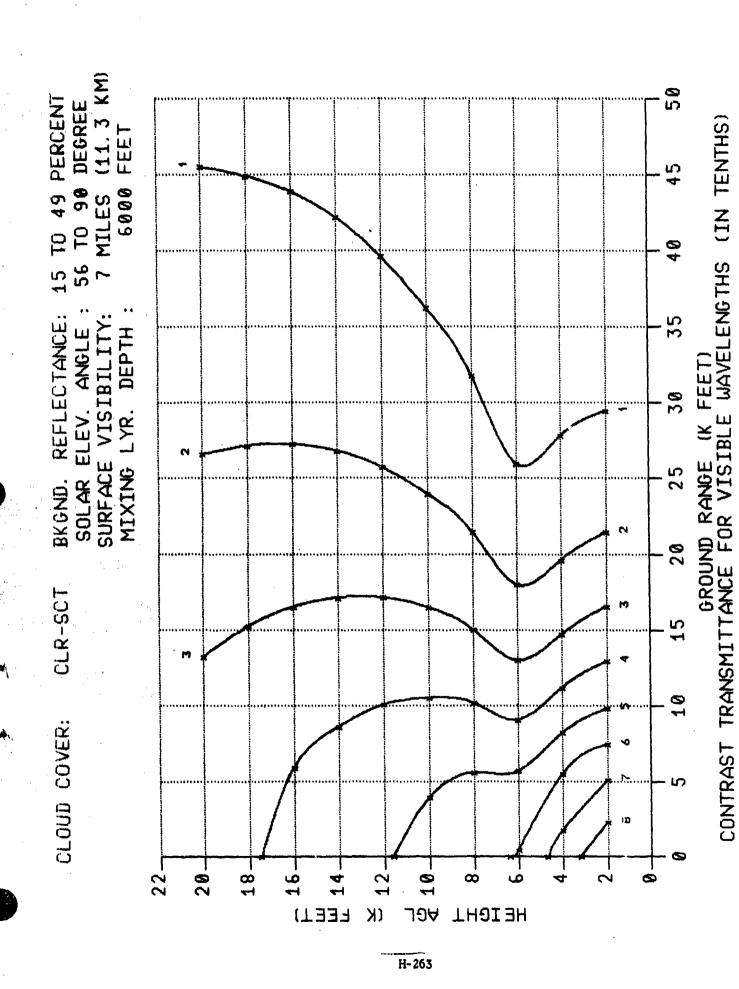


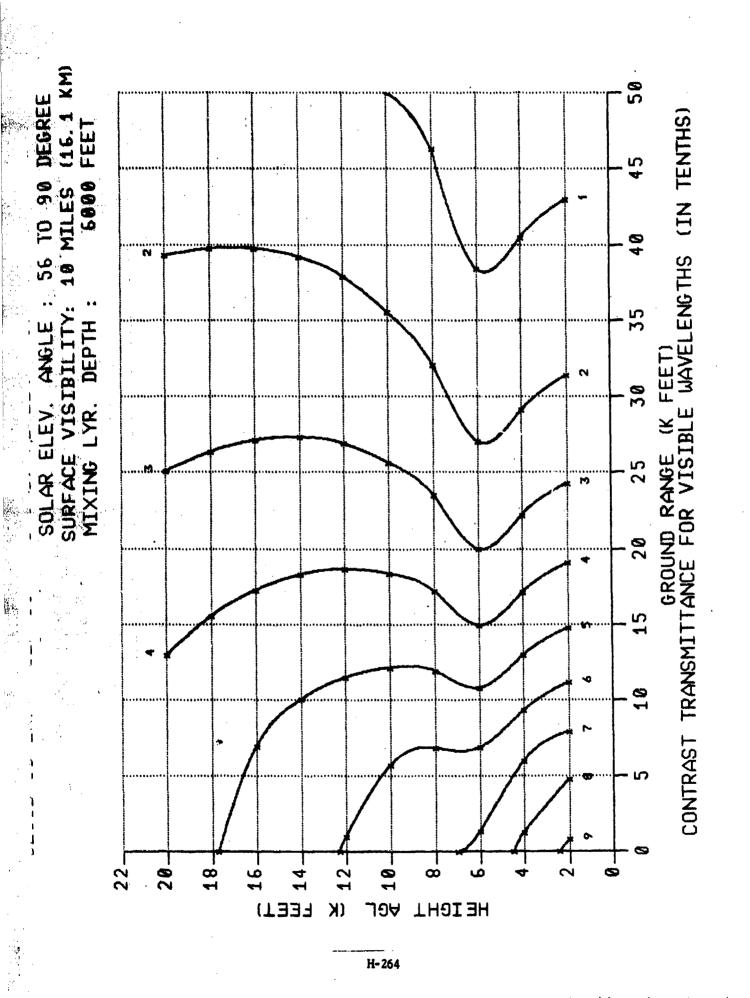


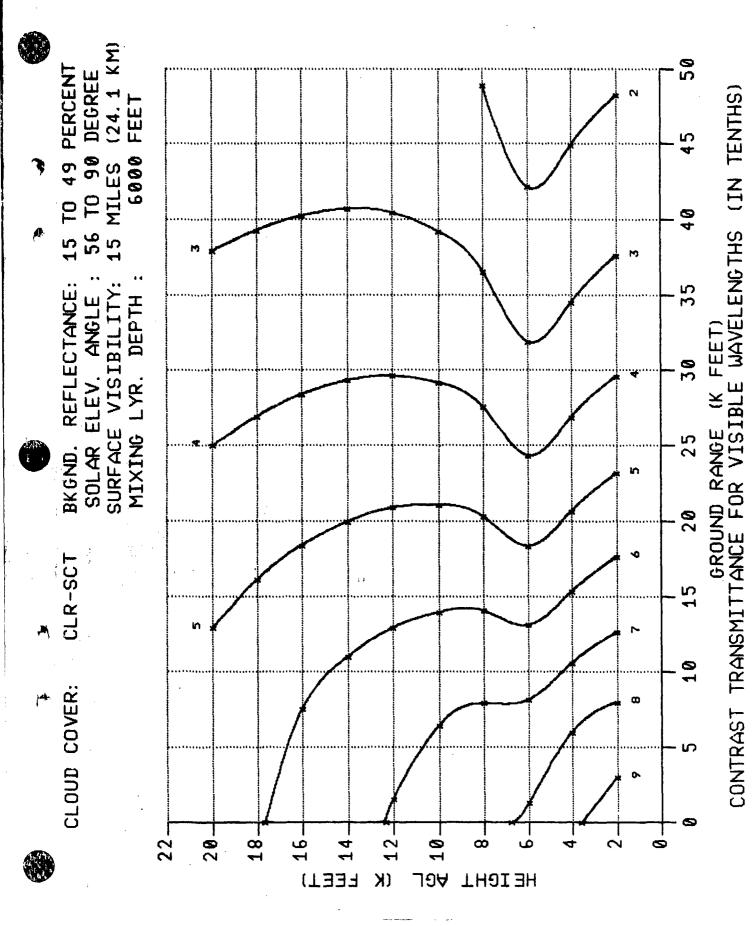
H-261

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

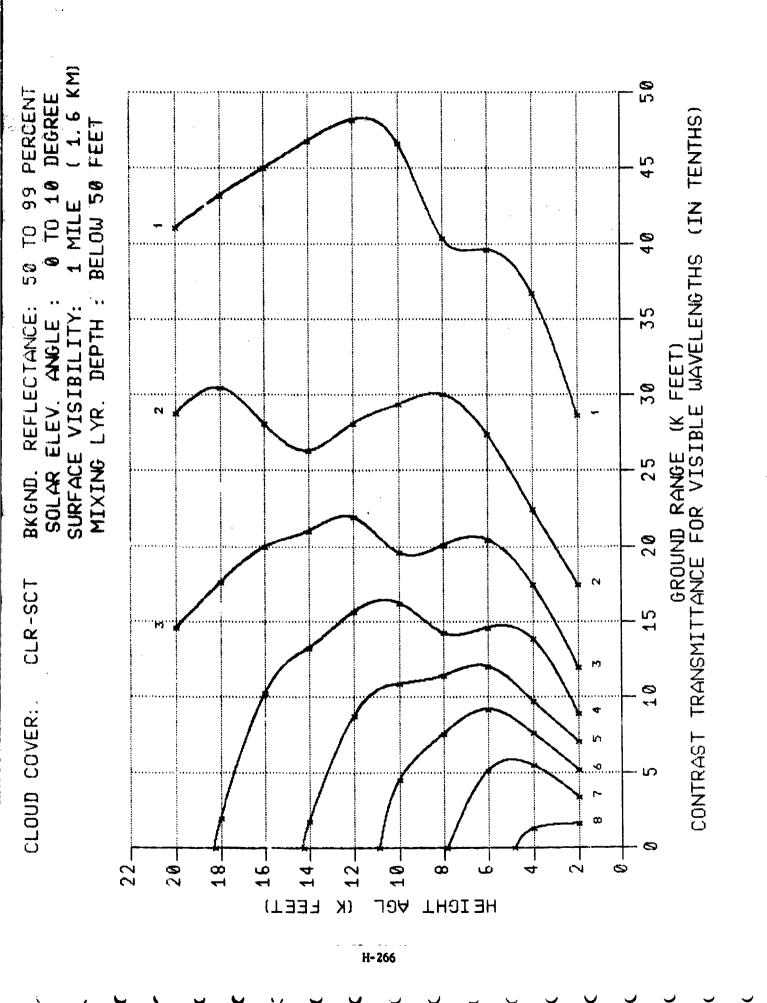


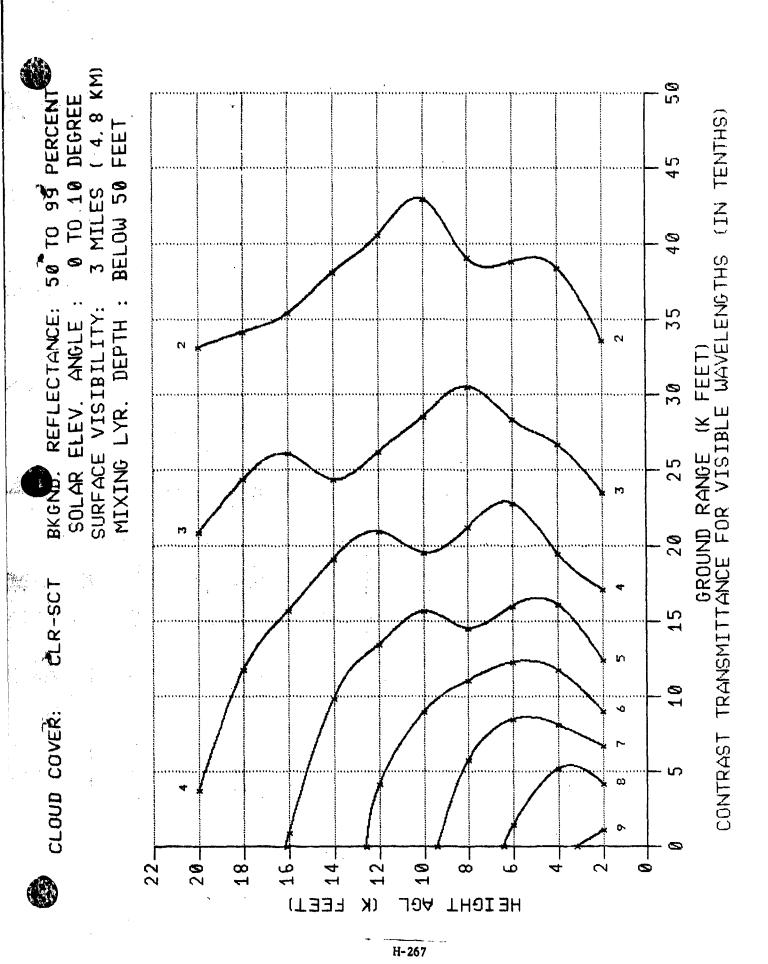


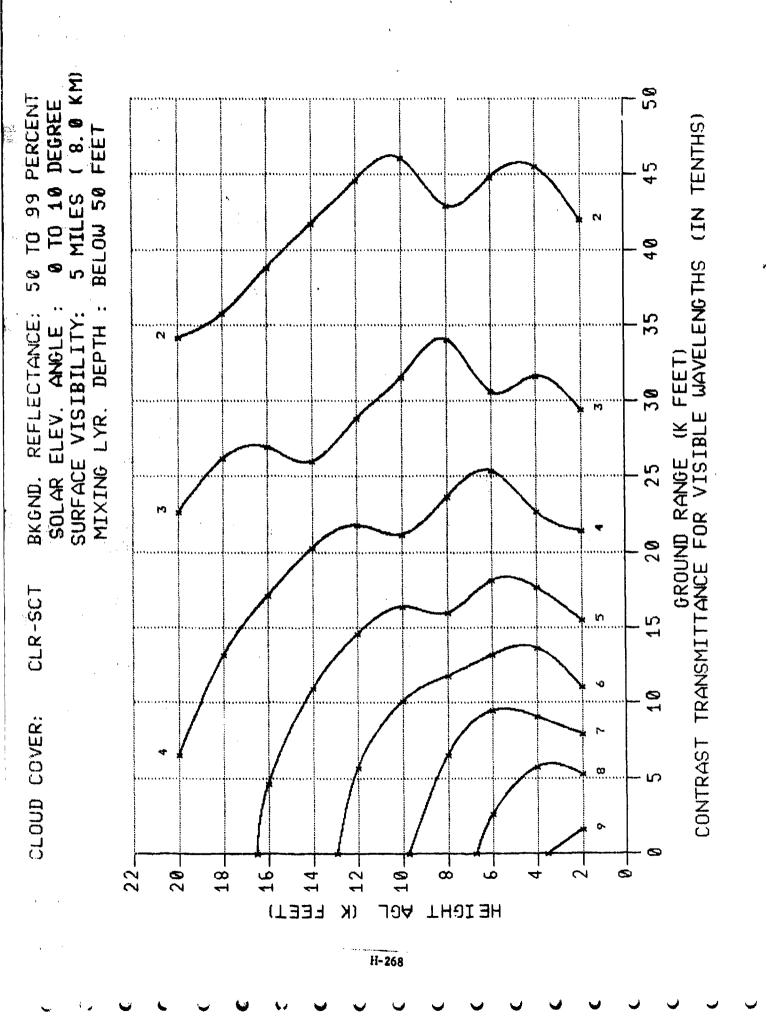




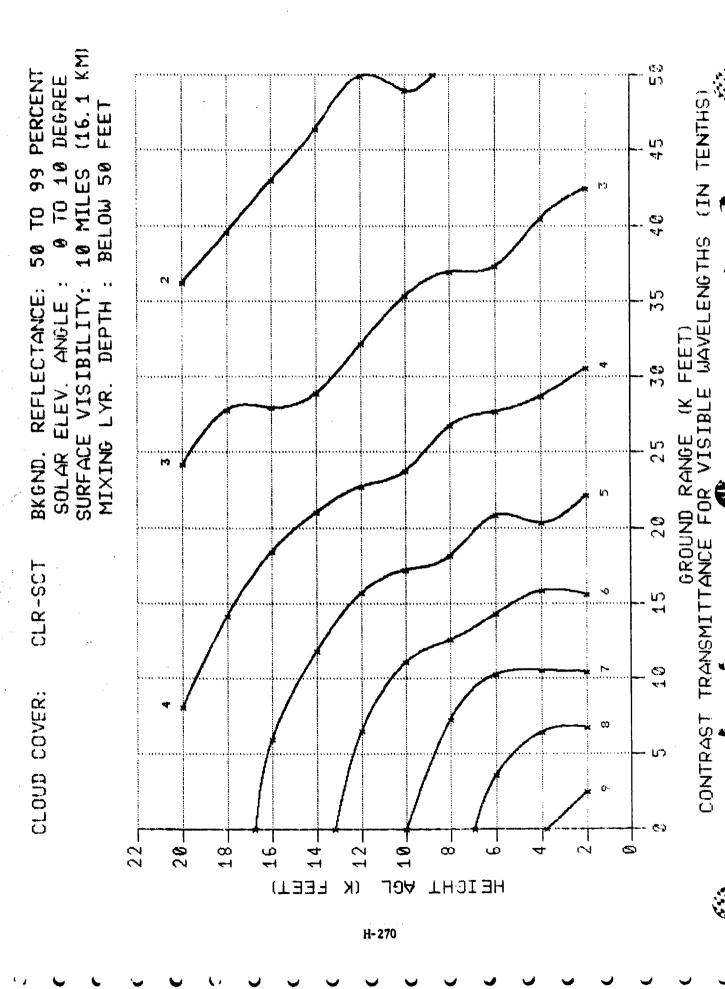
H-265

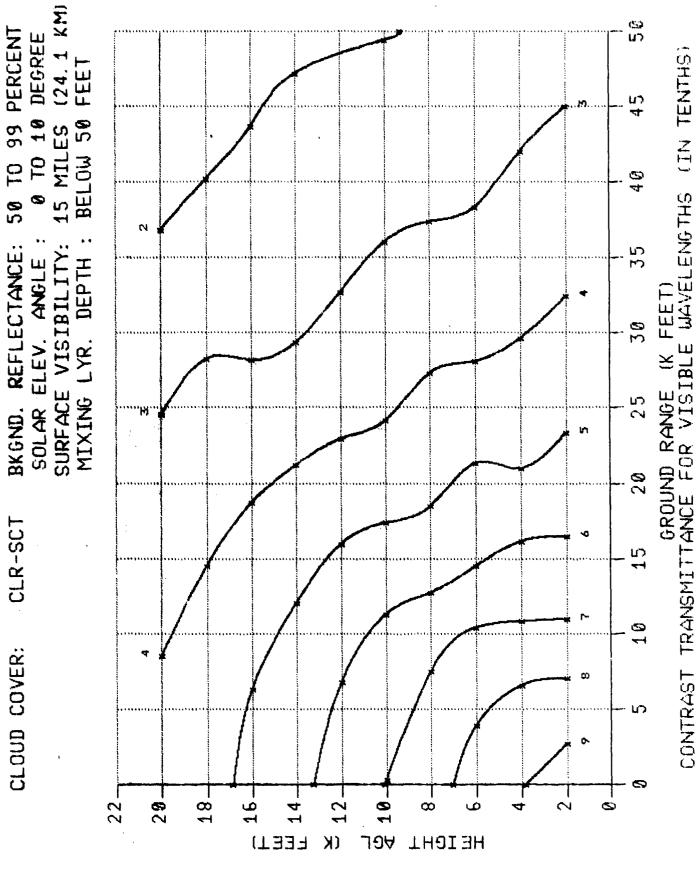




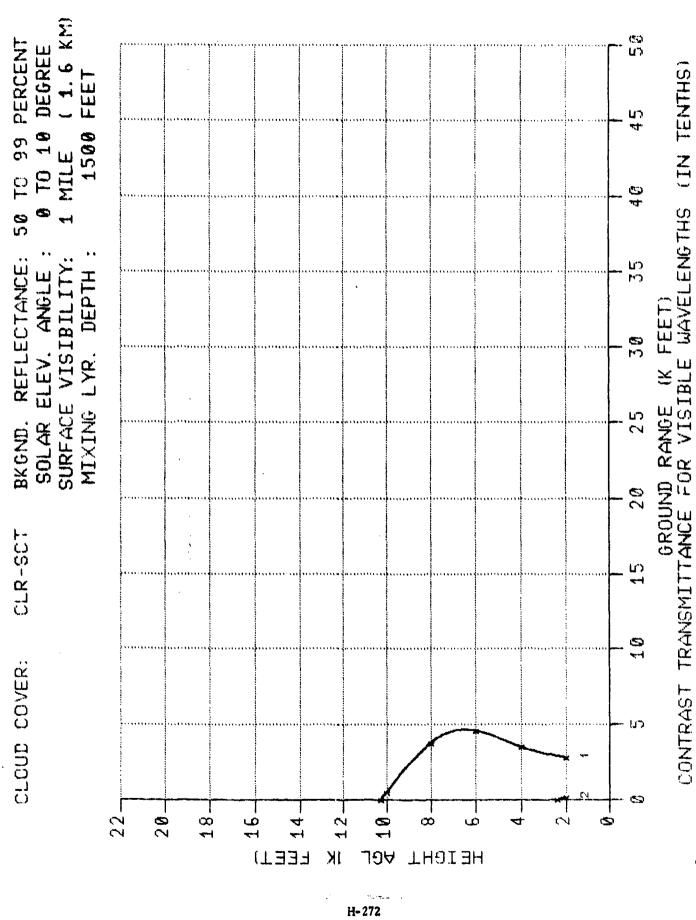


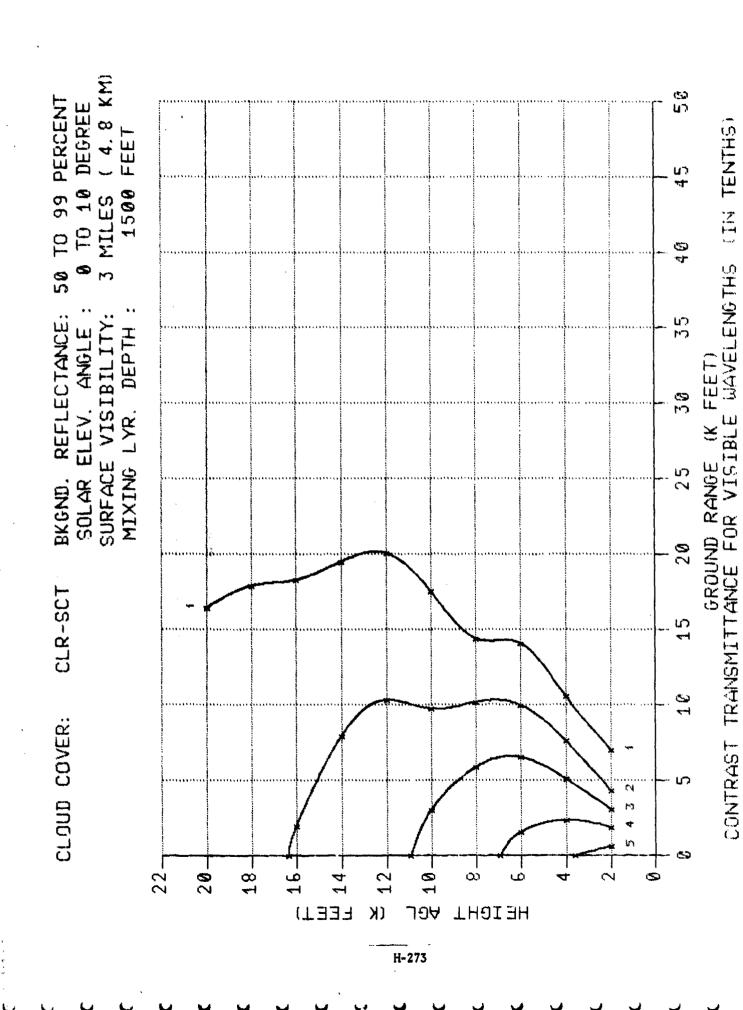
 $\frac{2}{2}$ 99 PERCENT 0 TO 10 DEGREE (11.3 FEET ሀን ተተ BELOW 50 7 MILES N REFLECTANCE: SURFACE VISIBILITY: MIXING LYR. DEPTH ELEV. ANGLE BKGND. SOLAR M CLR-SCT CLOUD COVER: 22 -20-



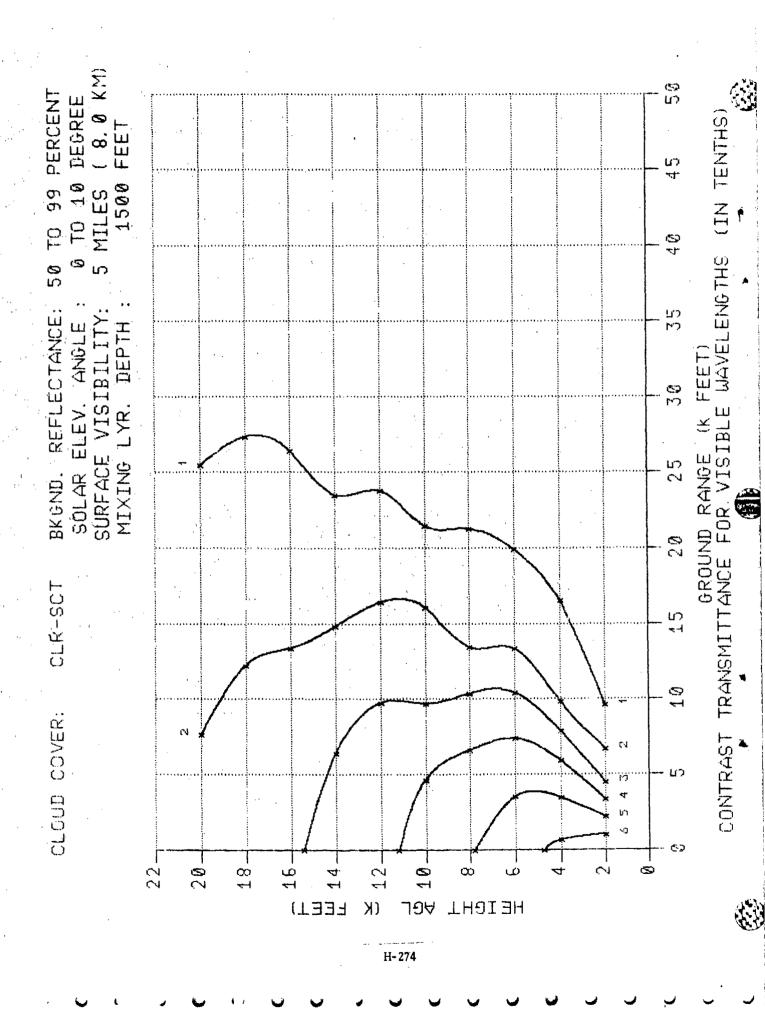


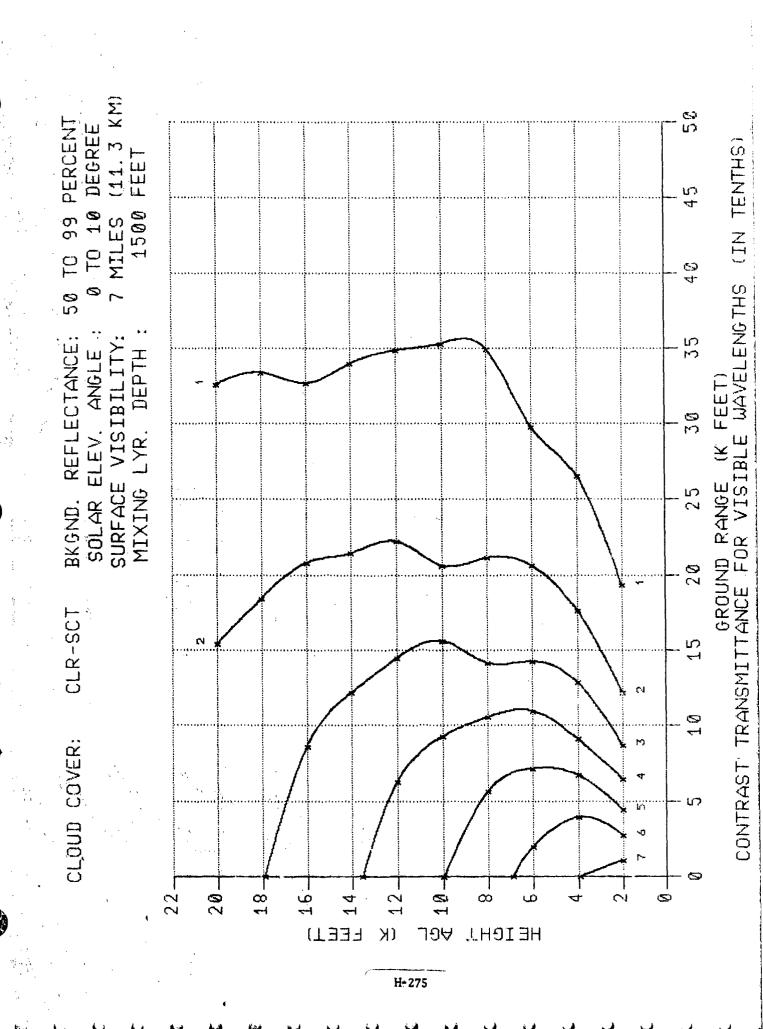
H-271

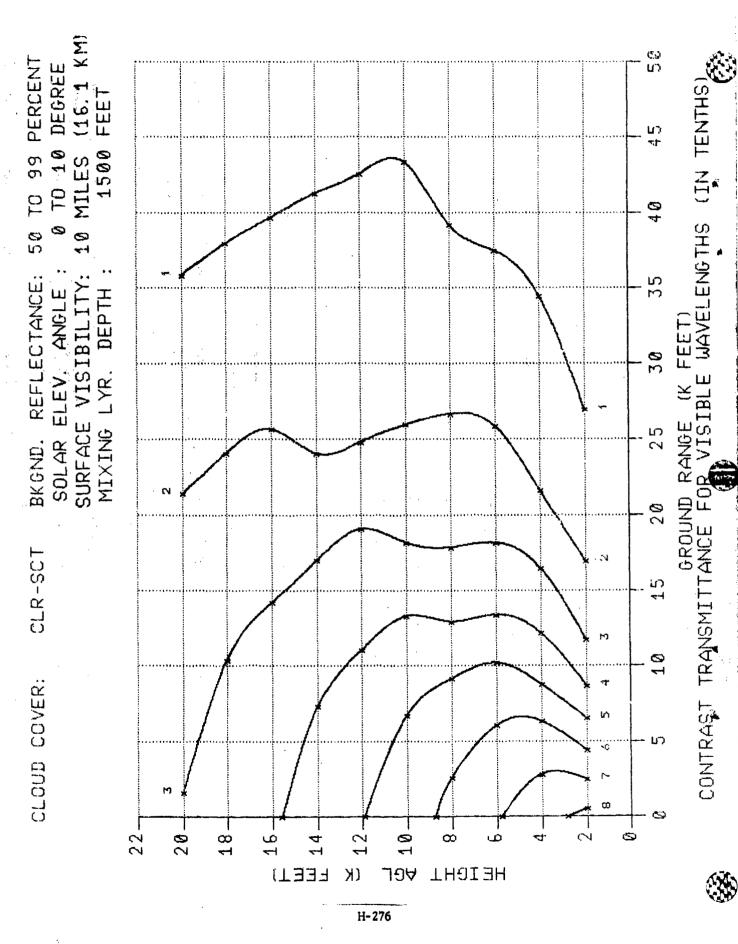




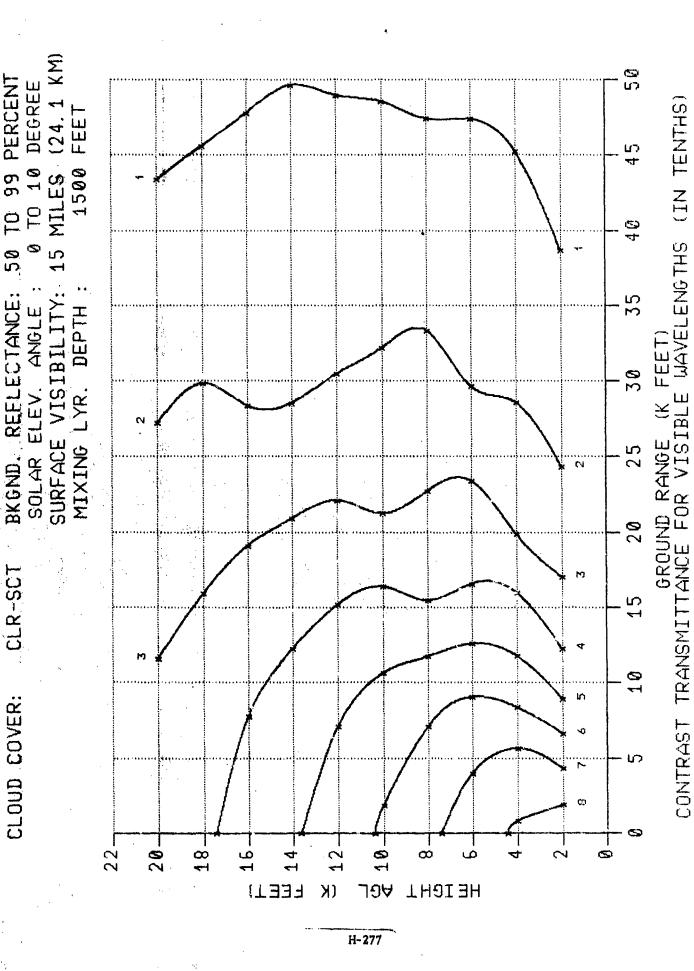
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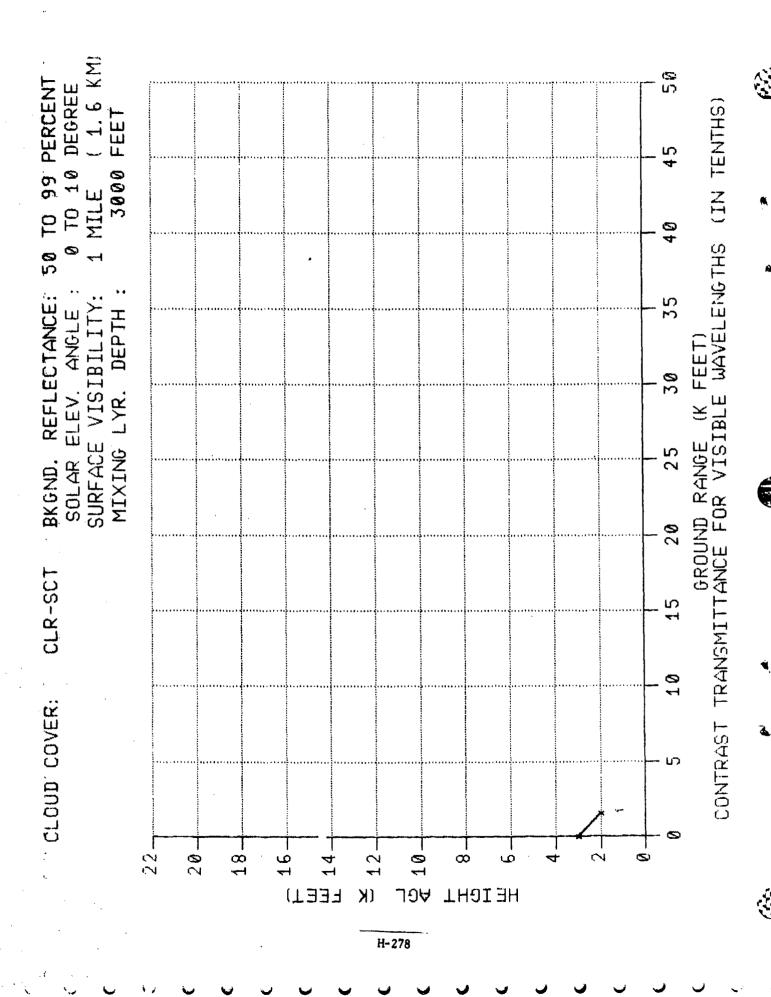


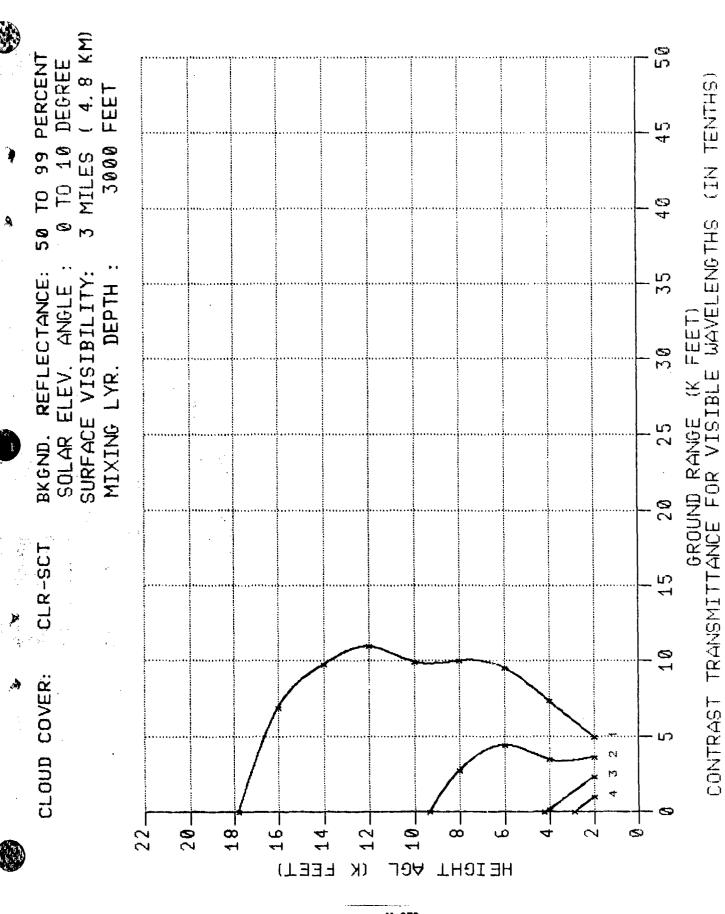
TO 99 PERCENT

(S)

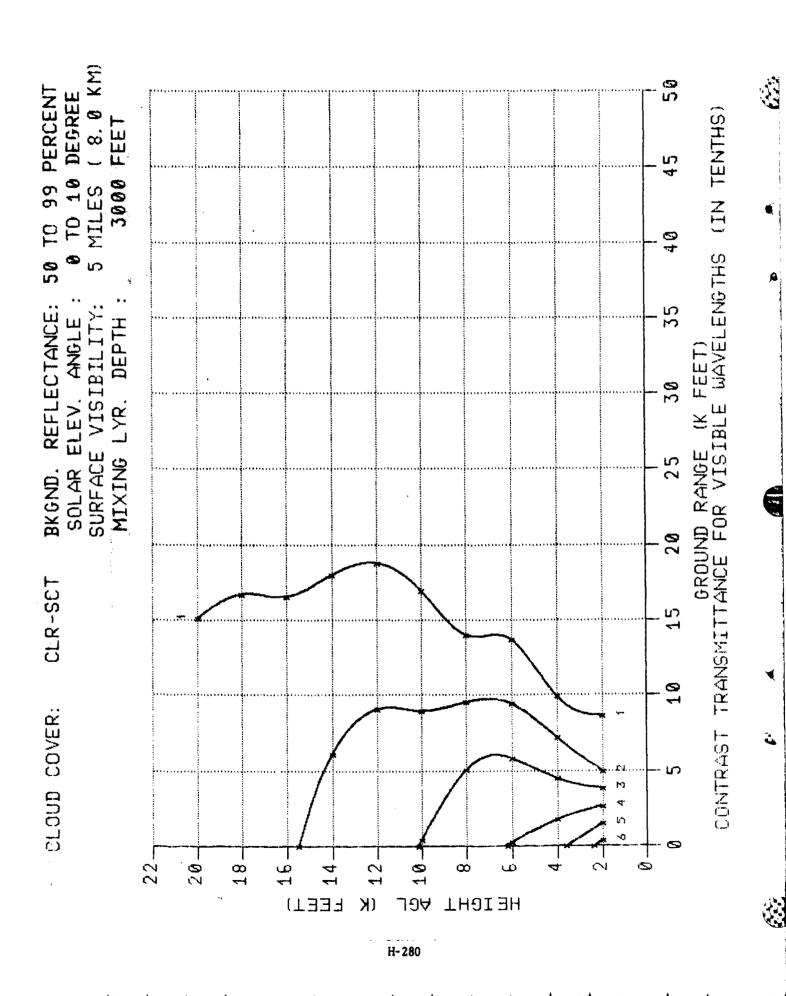
CLR-SCT

CLOUD COVER:

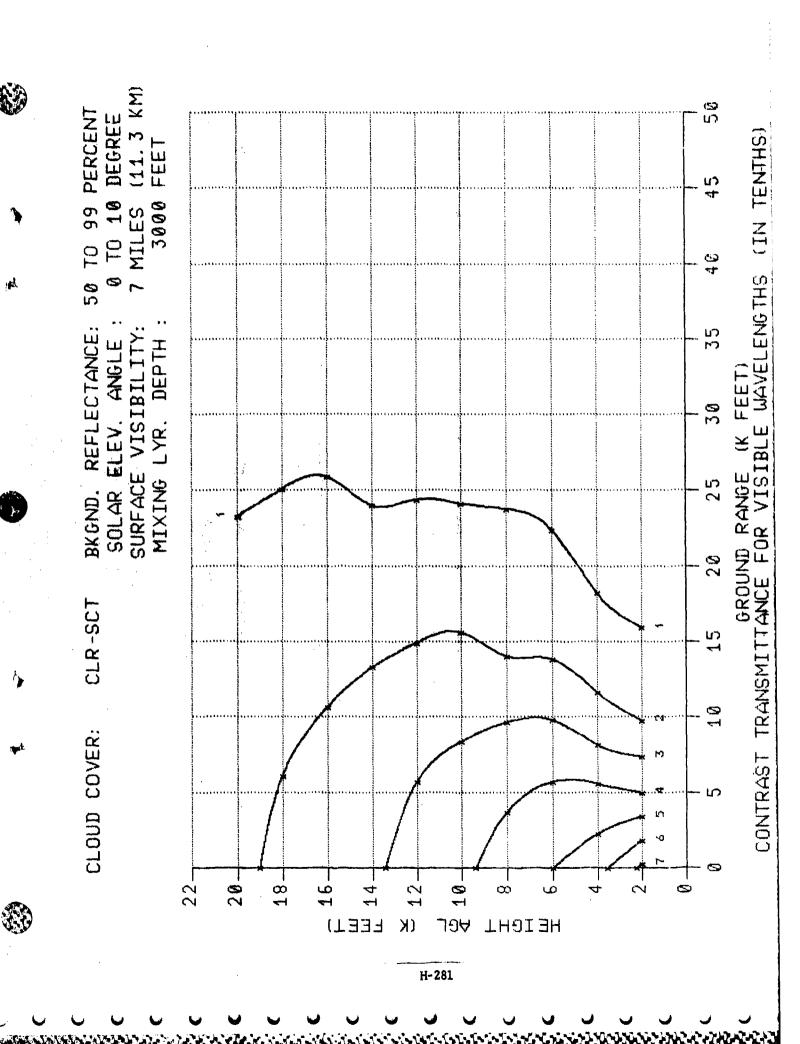


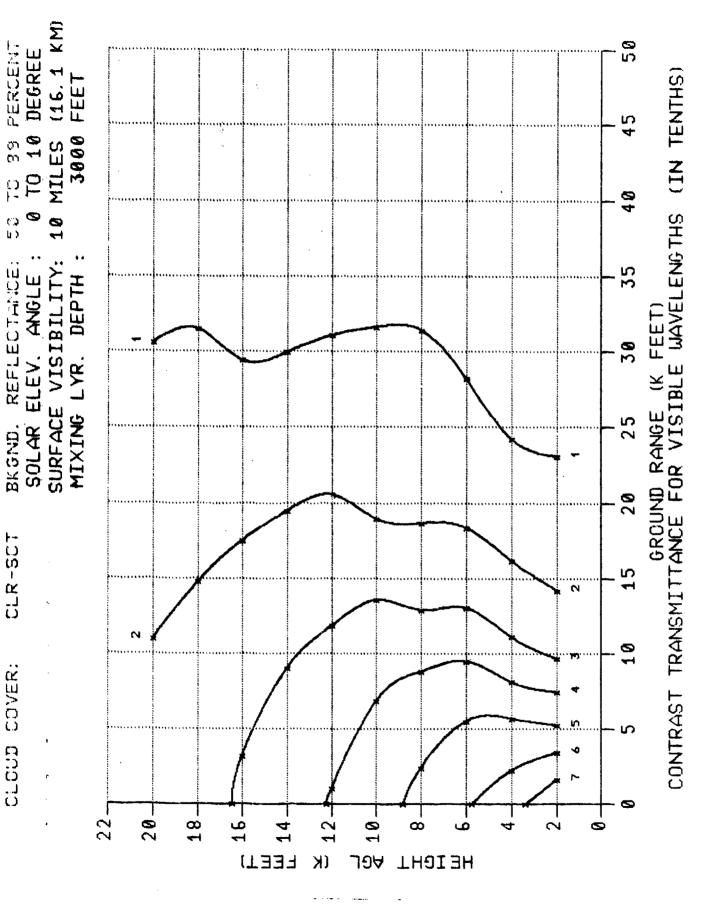


H-279

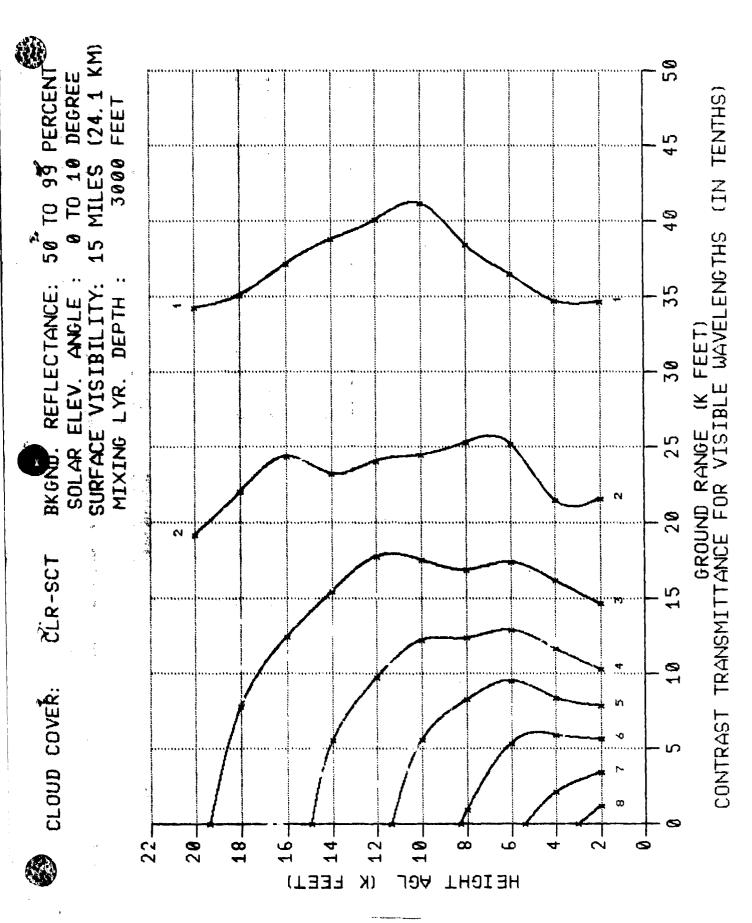


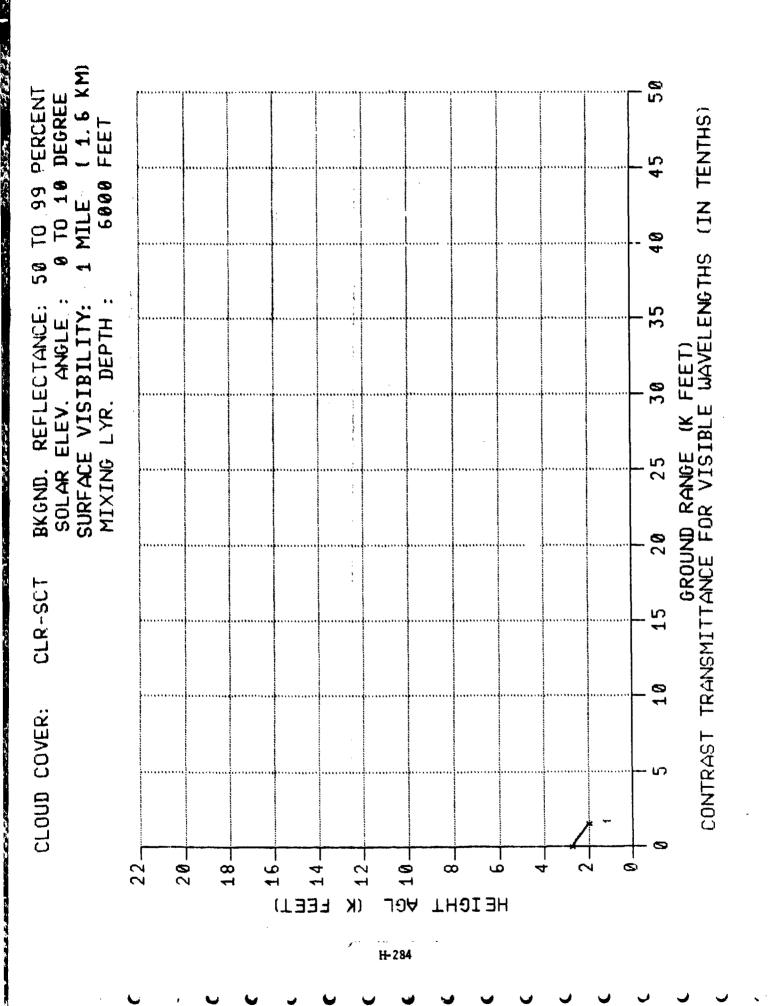
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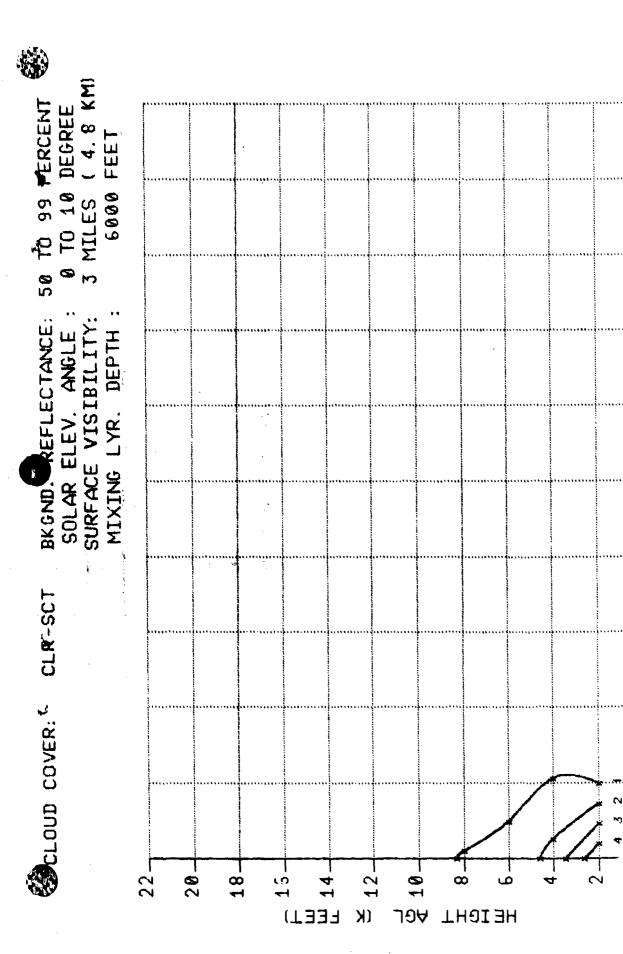




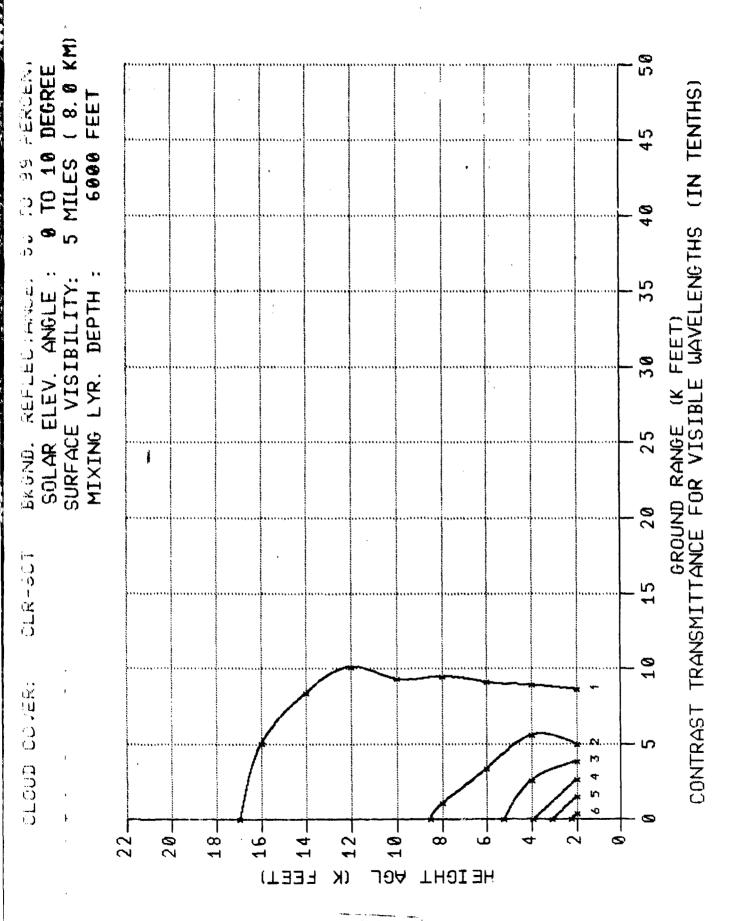
H-282



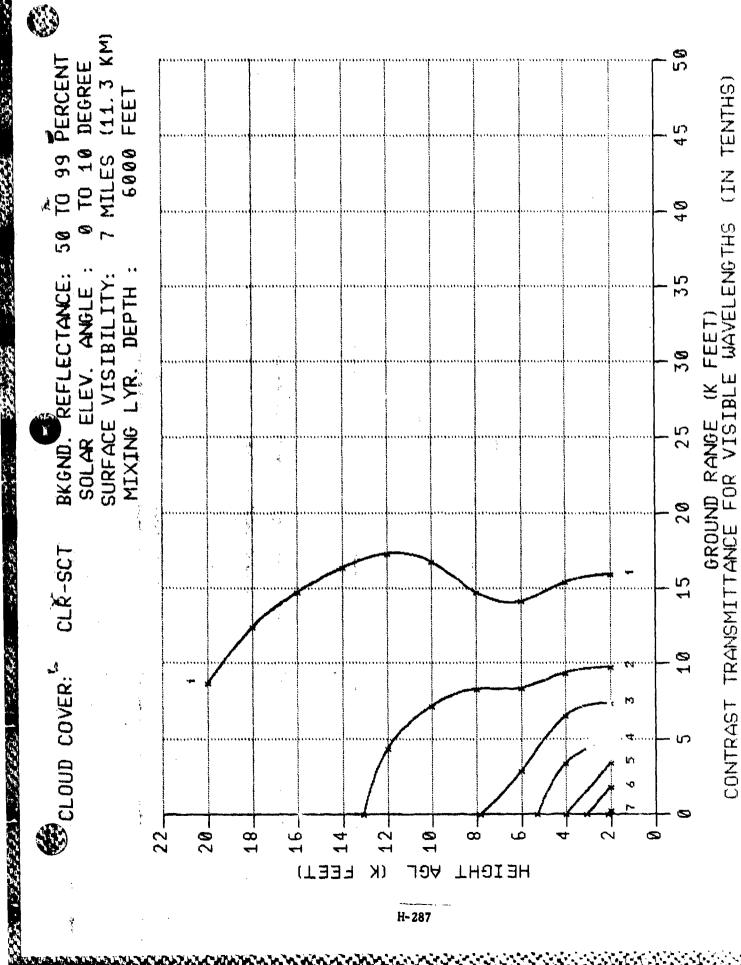




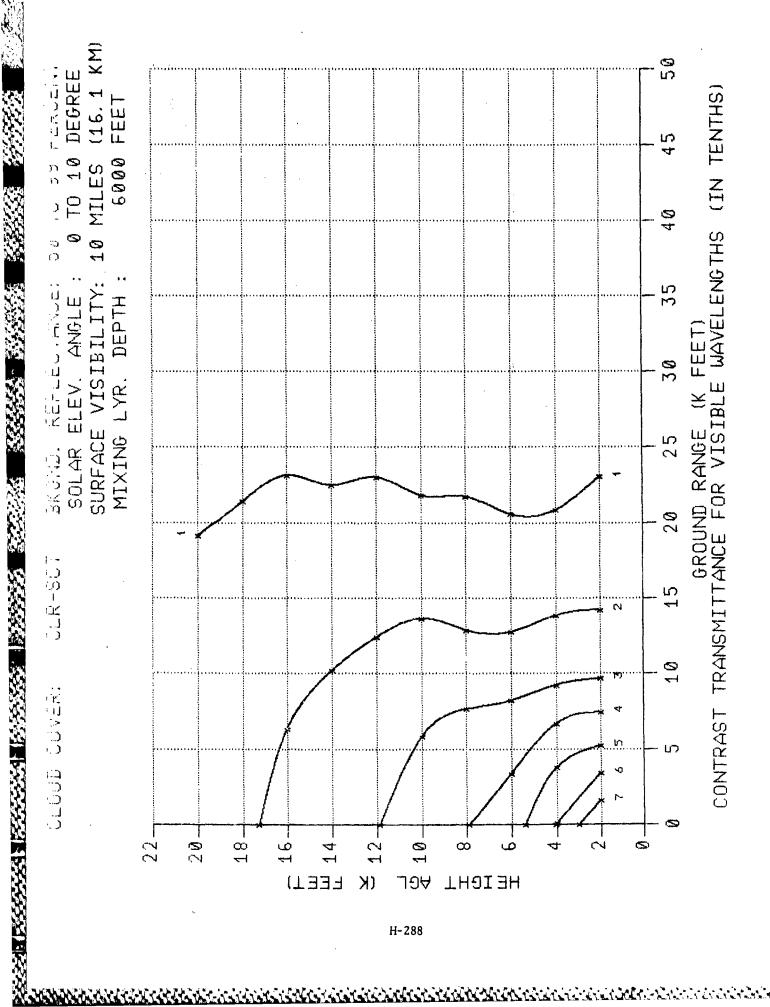
GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

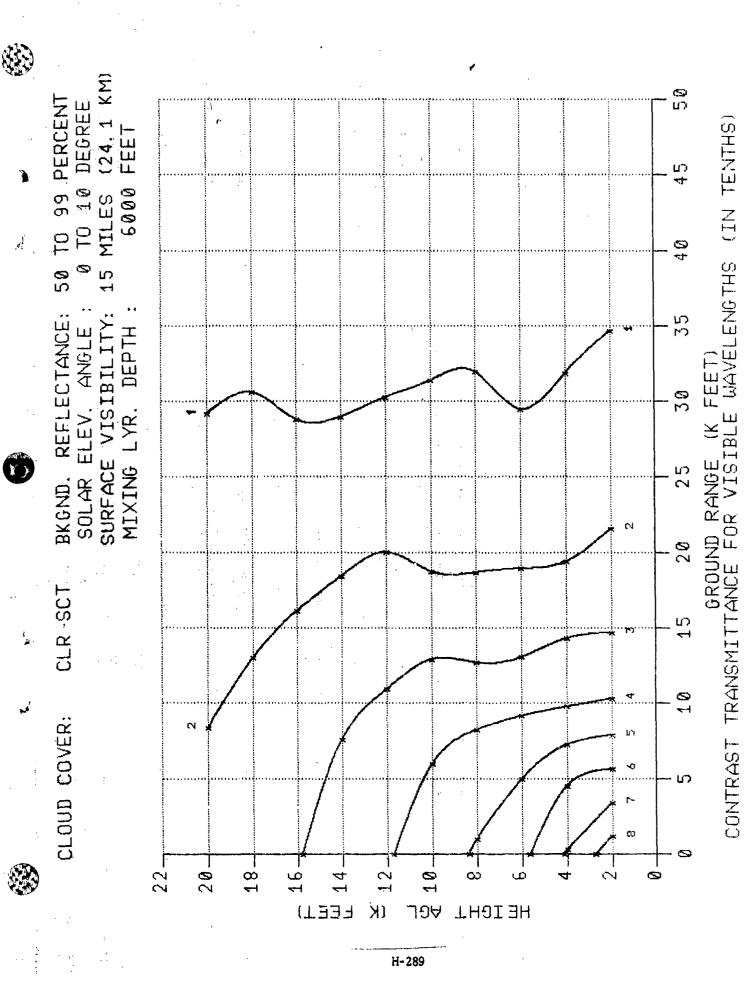


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H-287

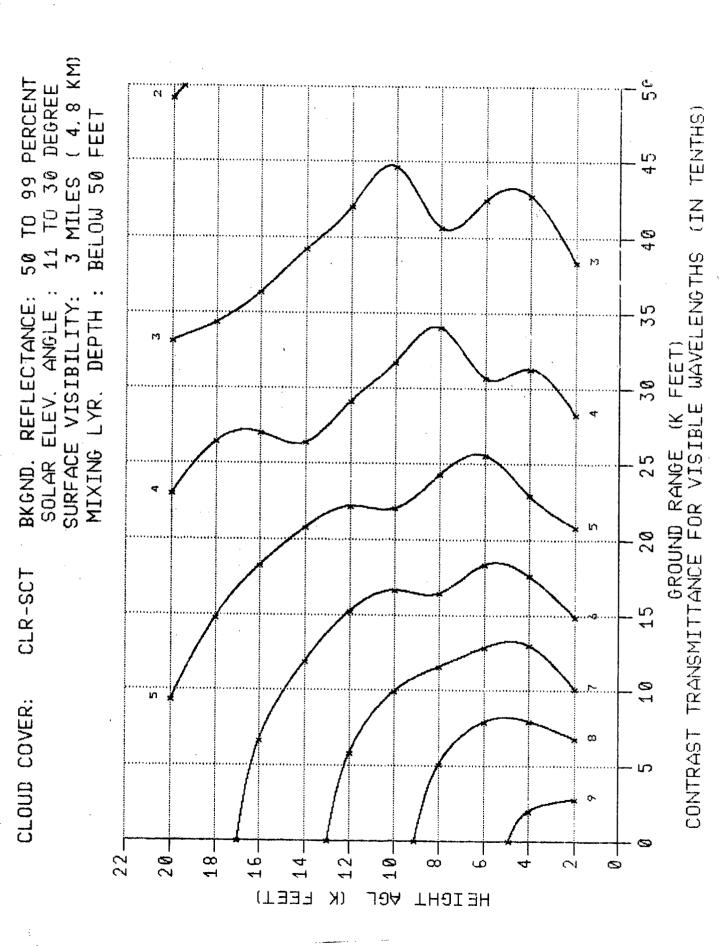


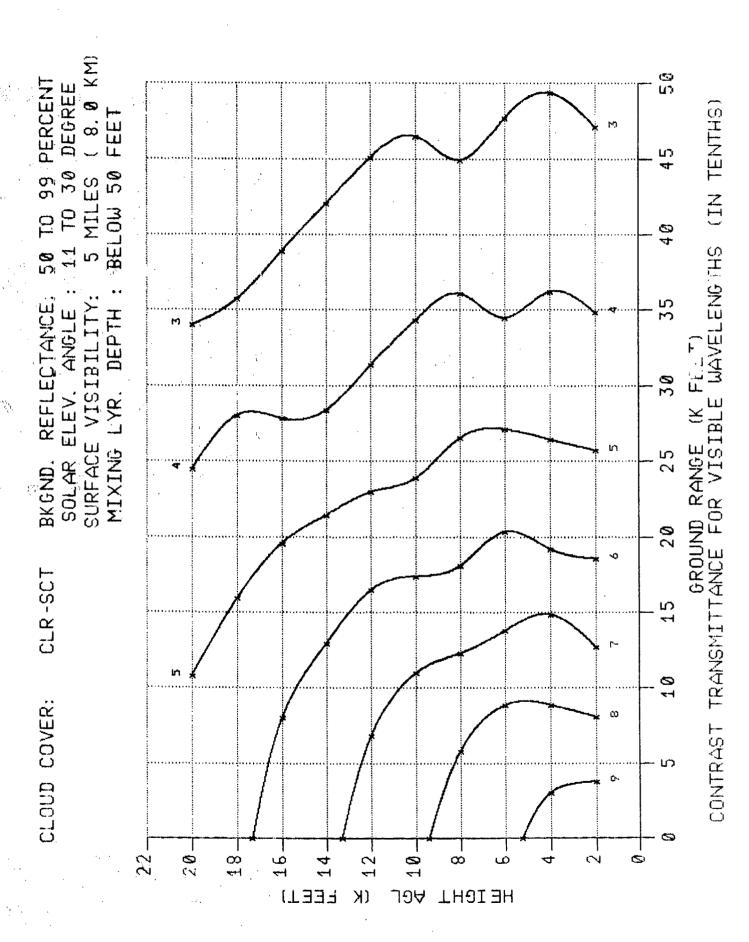


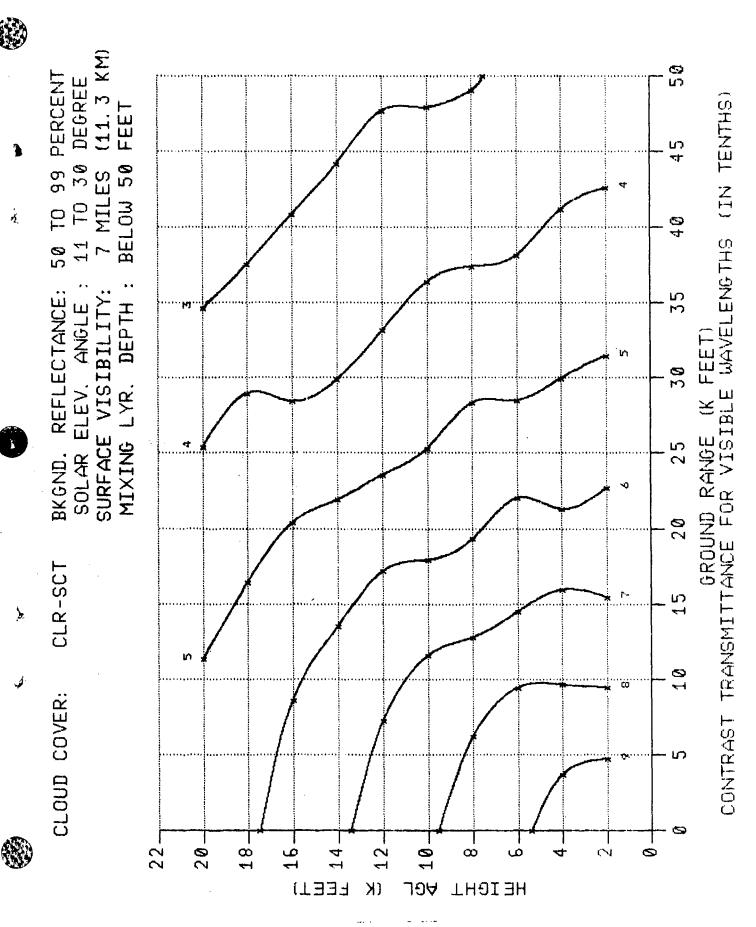
30 DEGREE .E ( 1.6 KM) 50 FEET S TO 99 PERCENT GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) 45 BELOW 50 1 MILE Ċ, REFLECTANCE; 35 SURFACE VISIBILITY: MIXING LYR. DEPTH SOLAR ELEV. ANGLE 30 BKGND. CLR-SCT CLOUD COVER: 16-12-22 -181 14-10-20 Ġ ထ 4 FEET) JÐA

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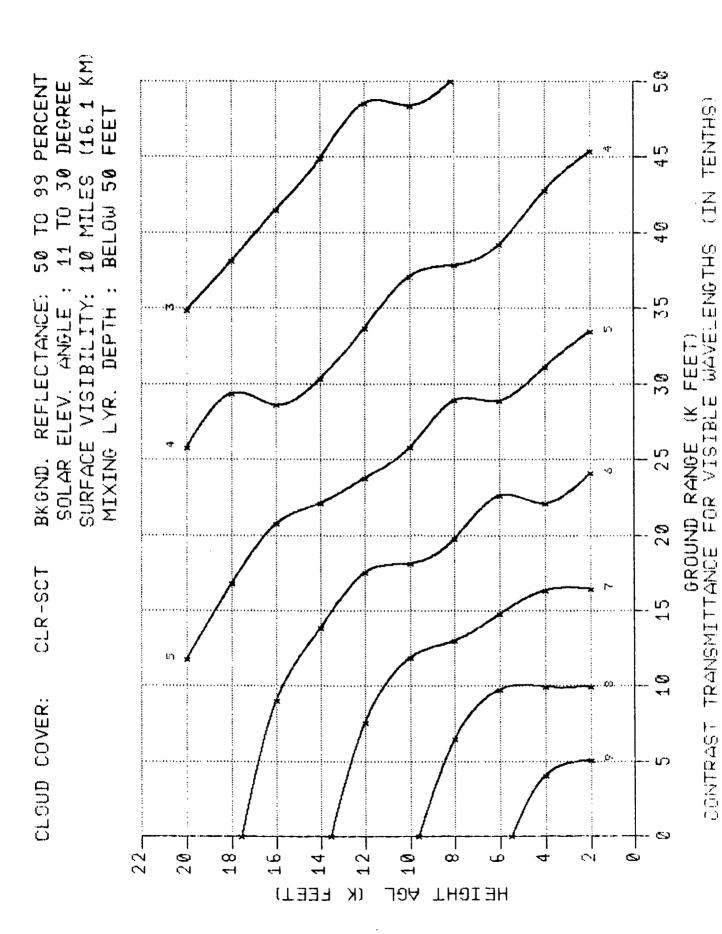
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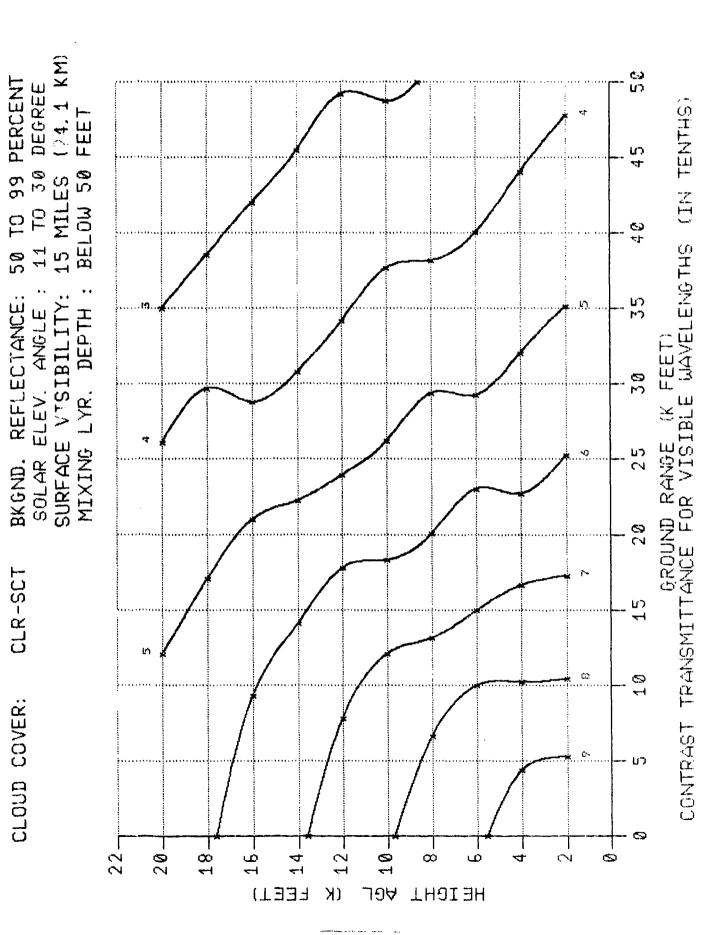


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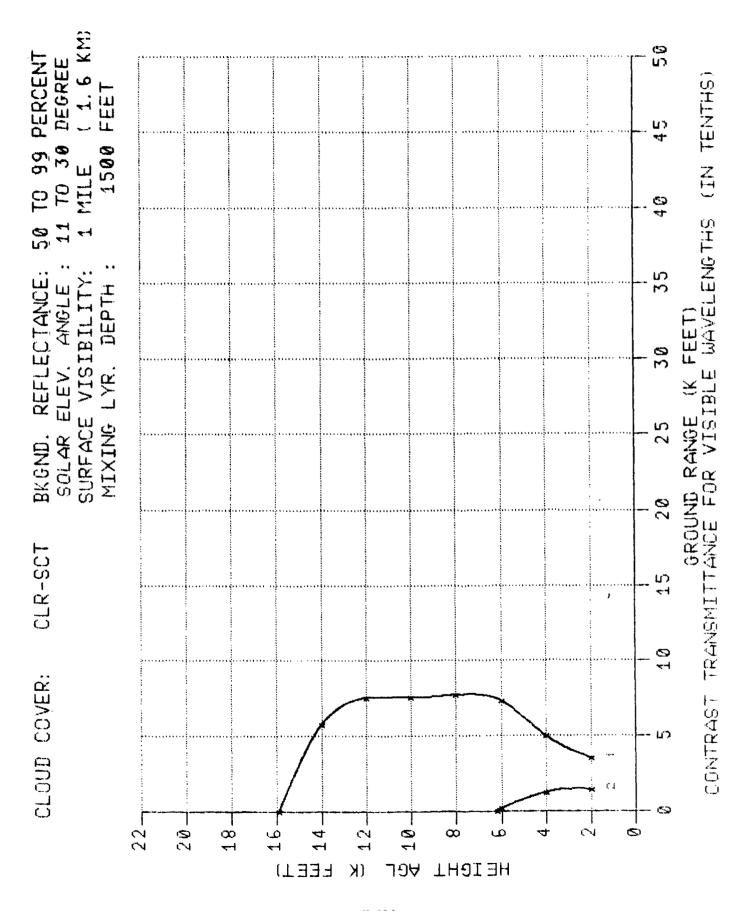
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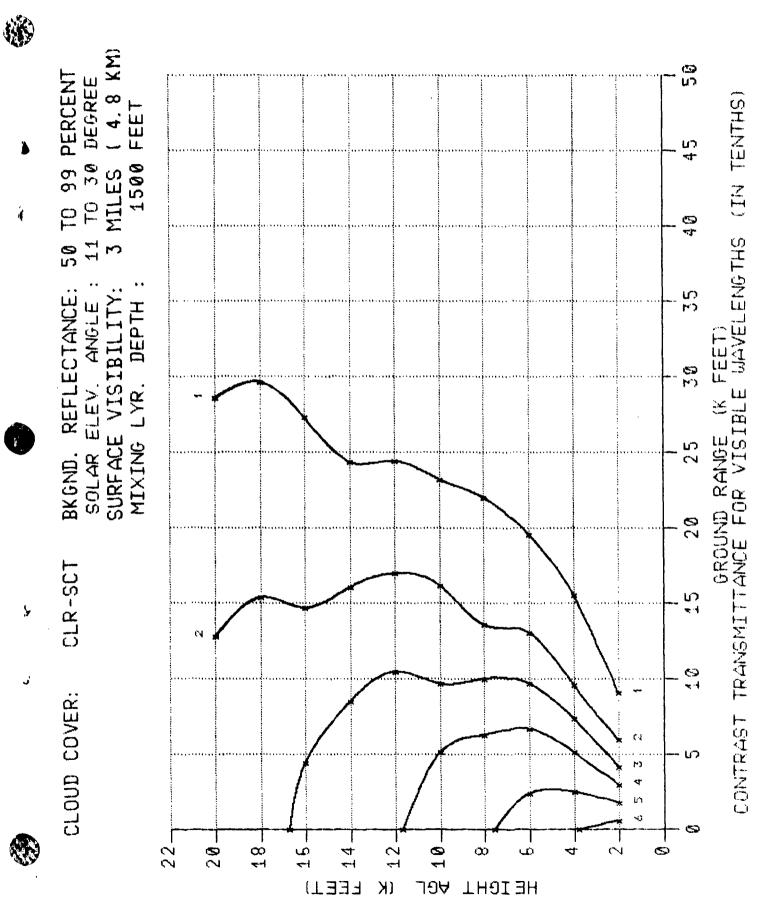
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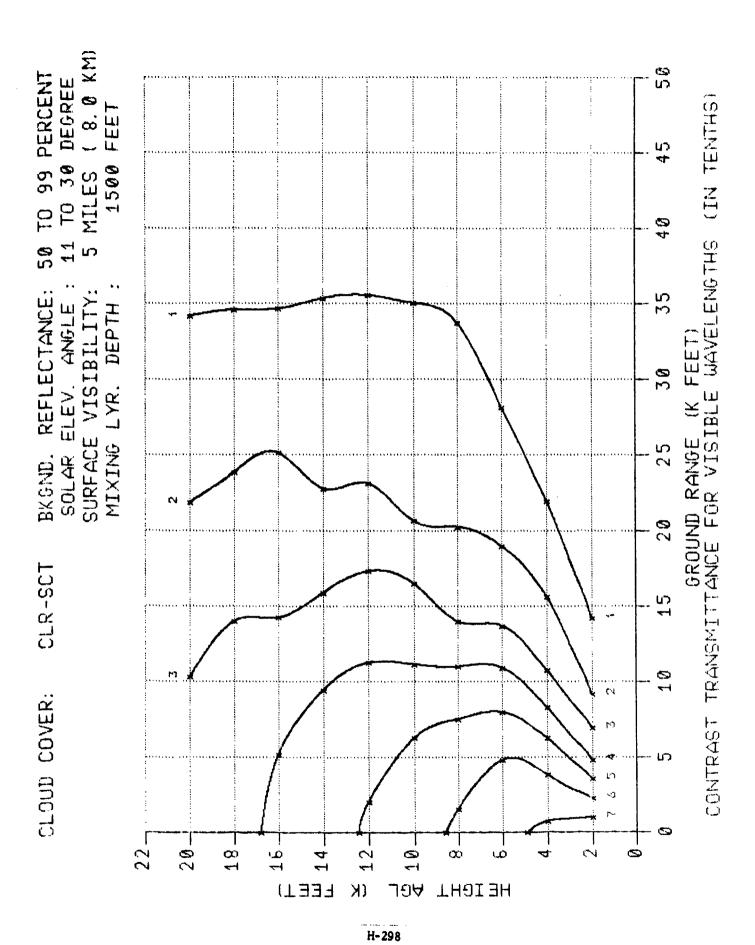


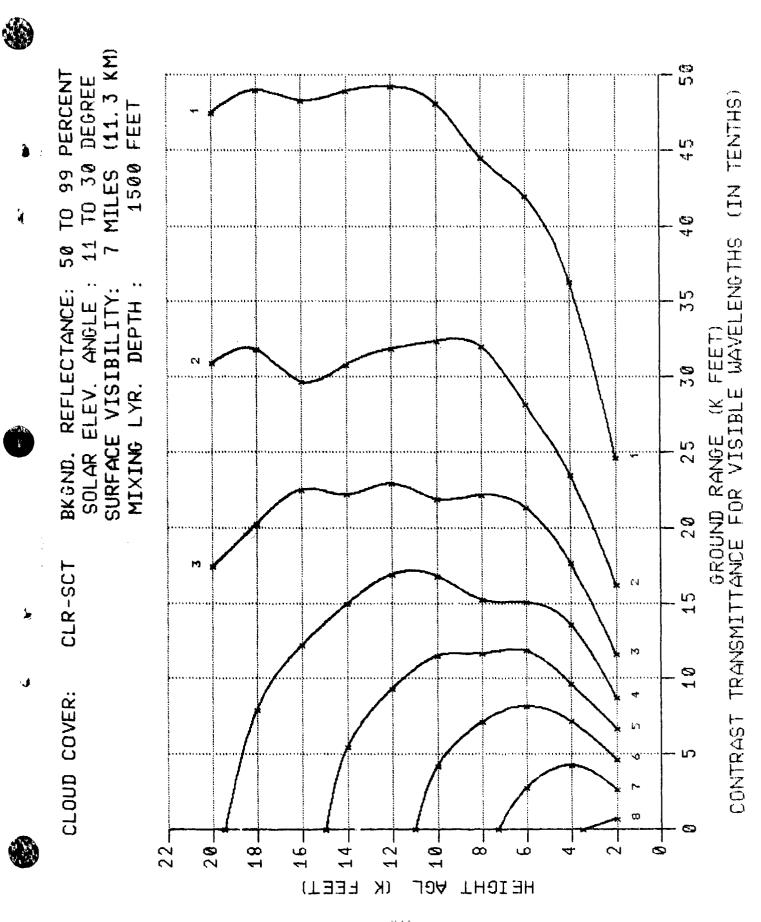
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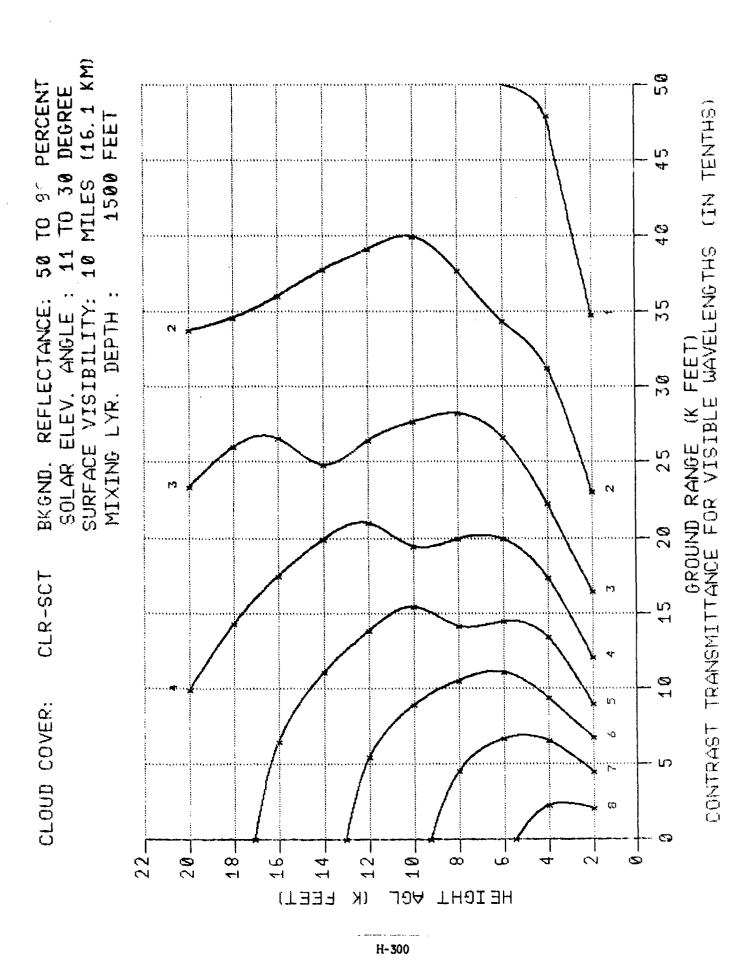
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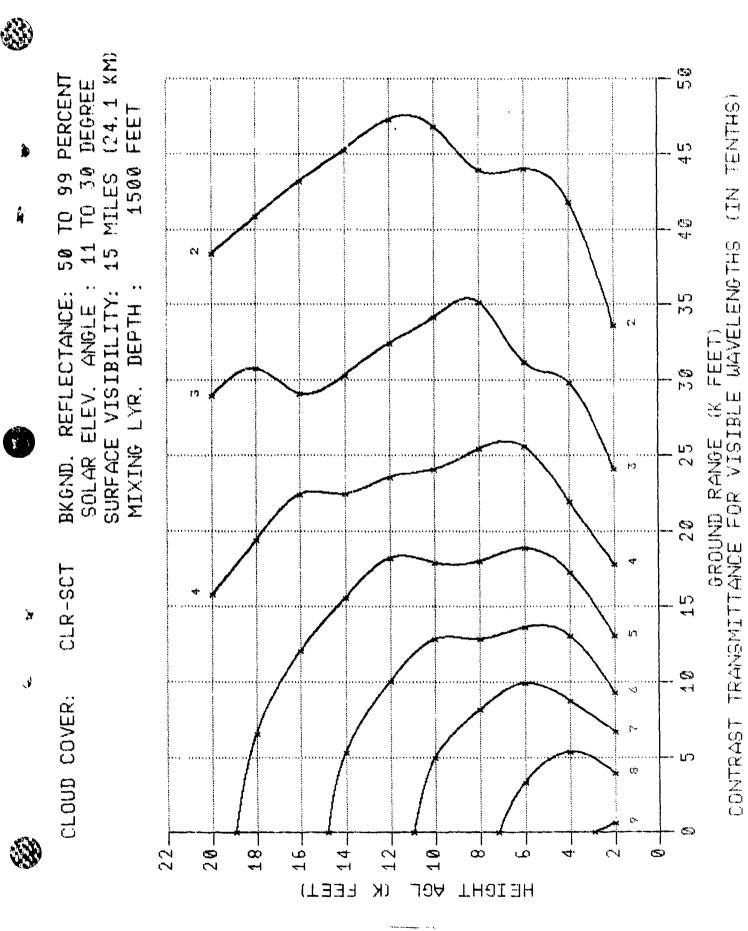


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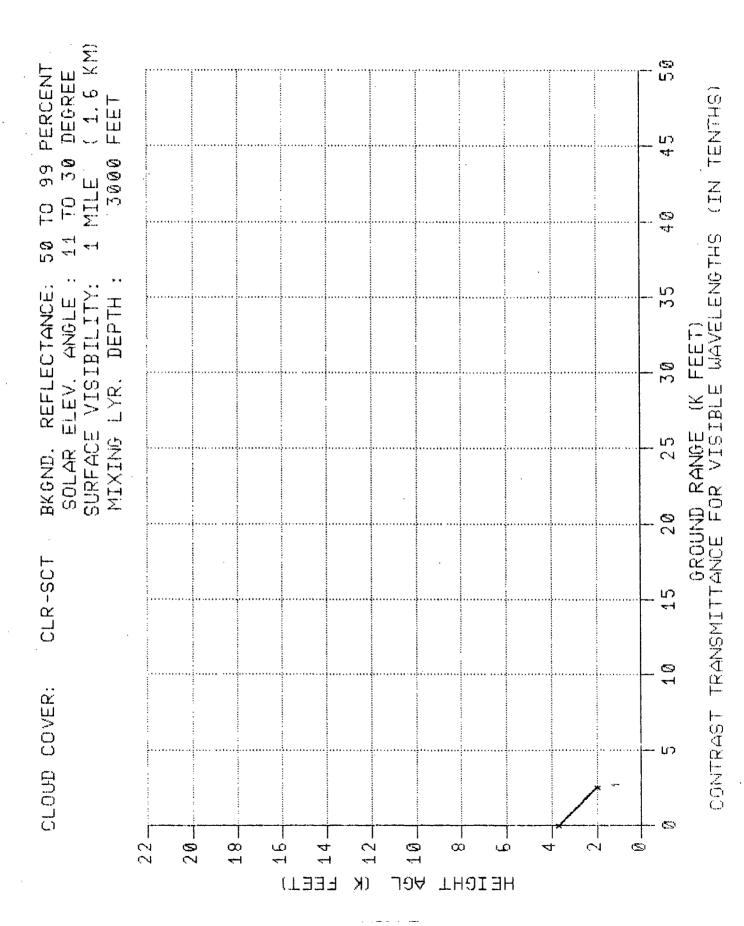




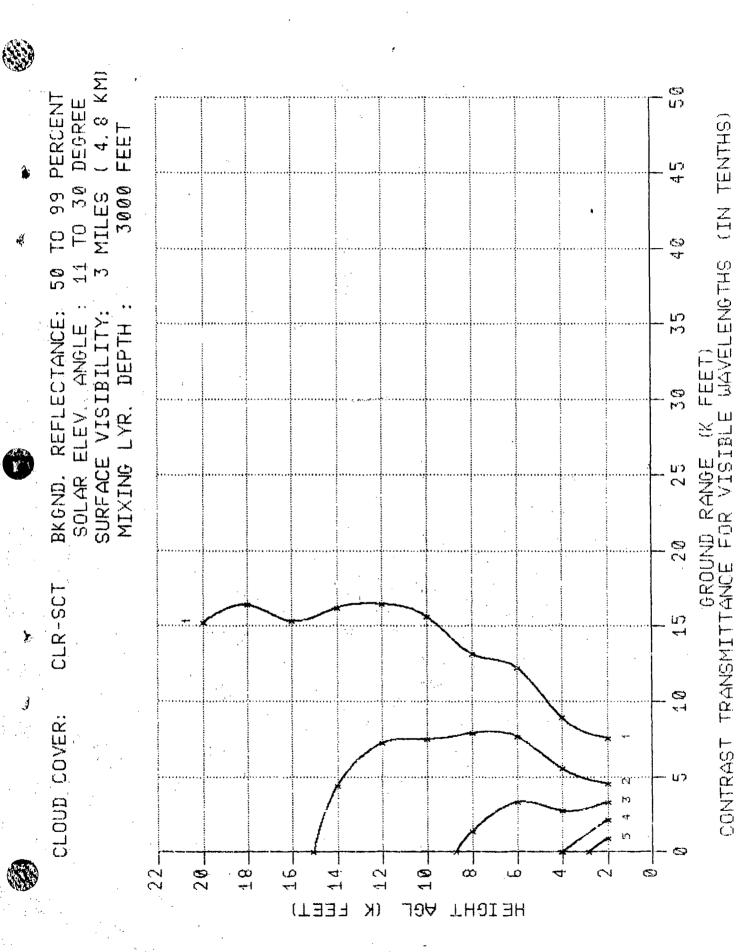




H-301

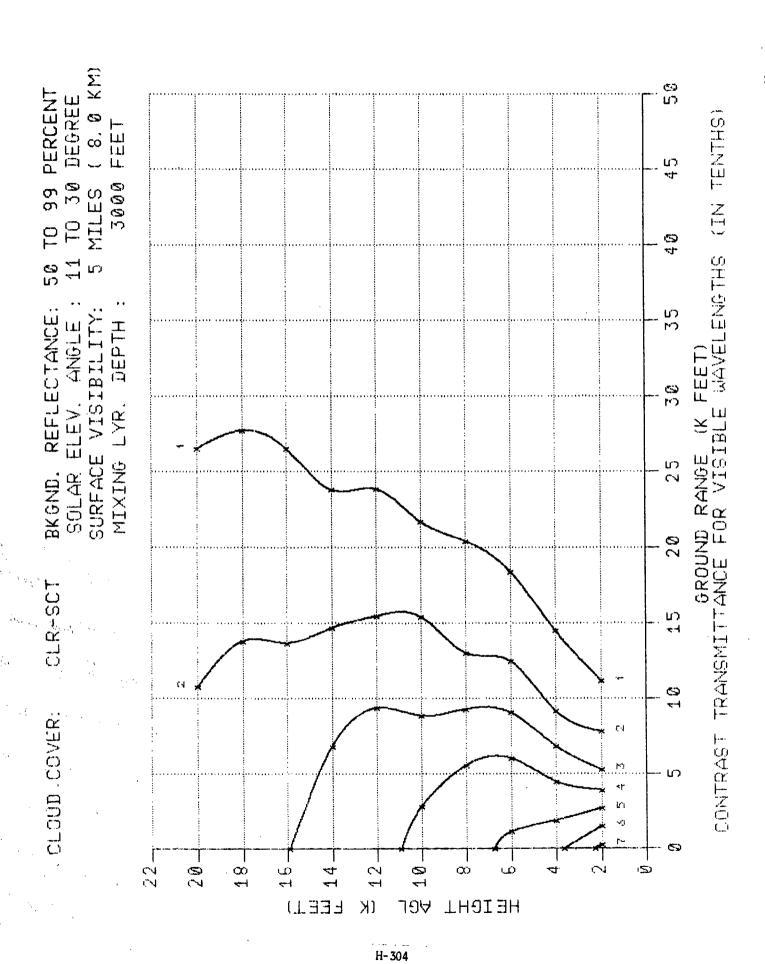


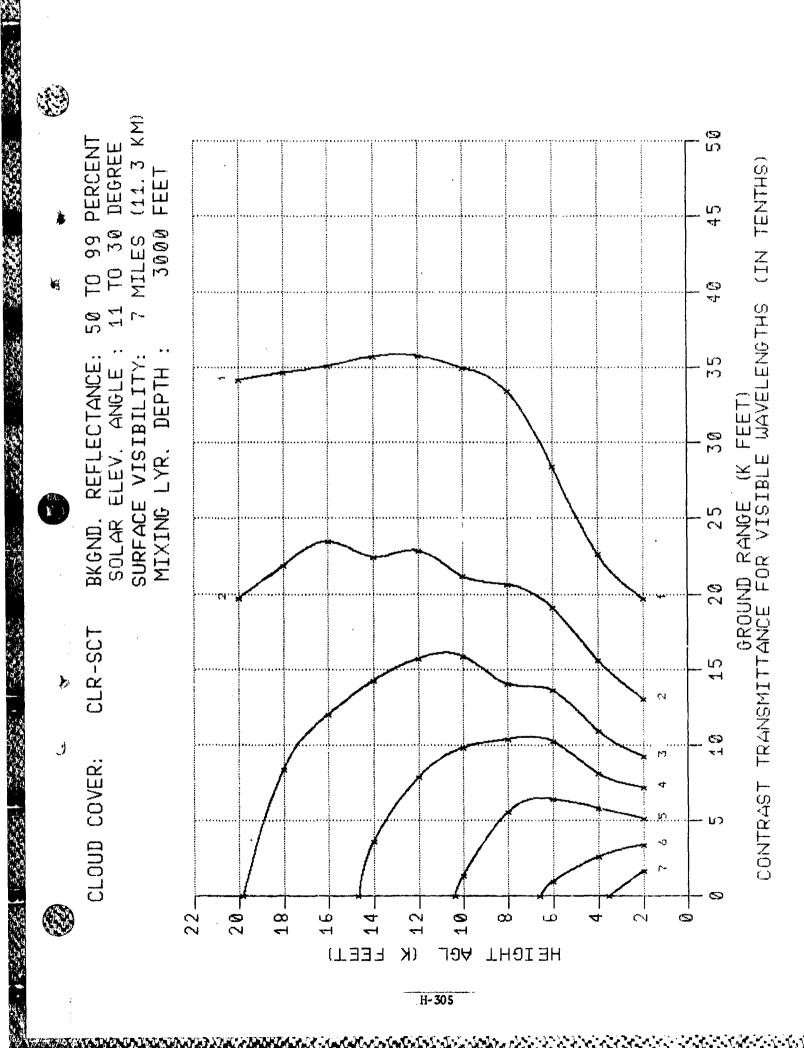
H-302

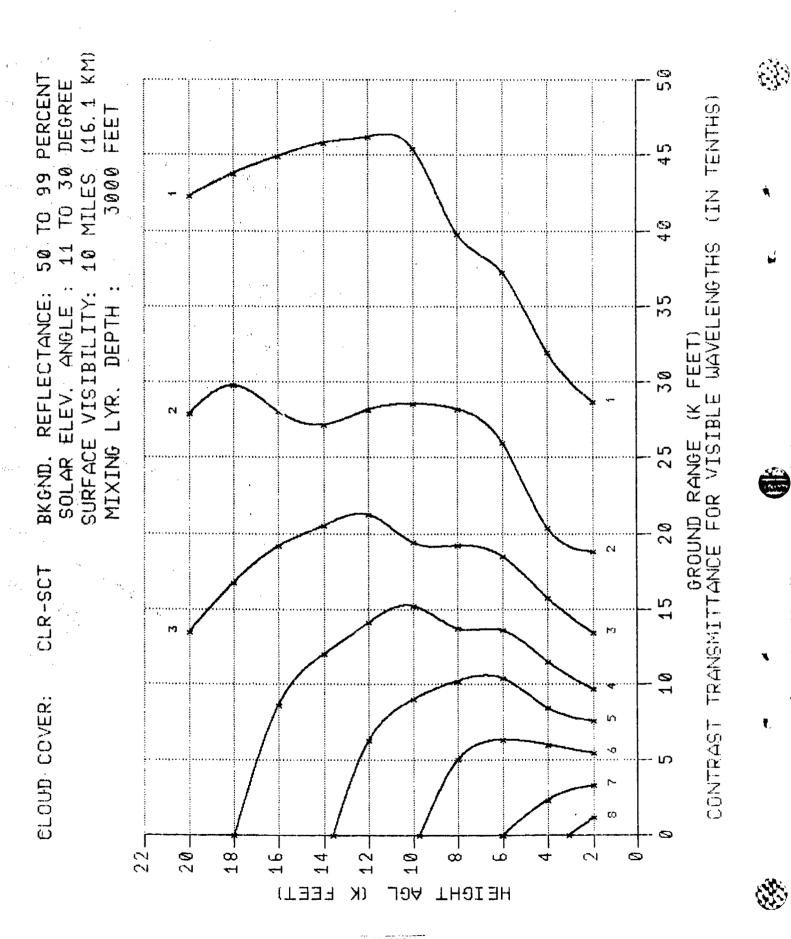


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(24, 1 KM) 99 PERCENT 30 DEGREE FEET 3000 15 MILES MIXING LYR. DEPTH: BKGND, REFLECTANCE: SOLAR ELEV, ANGLE : SURFACE VISIBILITY: CLR-SCT. CLOUD COVER:  $\varpi$ 20-□ ထ ٩ 6 4 10. 22. 48 16. 12. 14 (LEET) (K JĐ∀ HE ICHT

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GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

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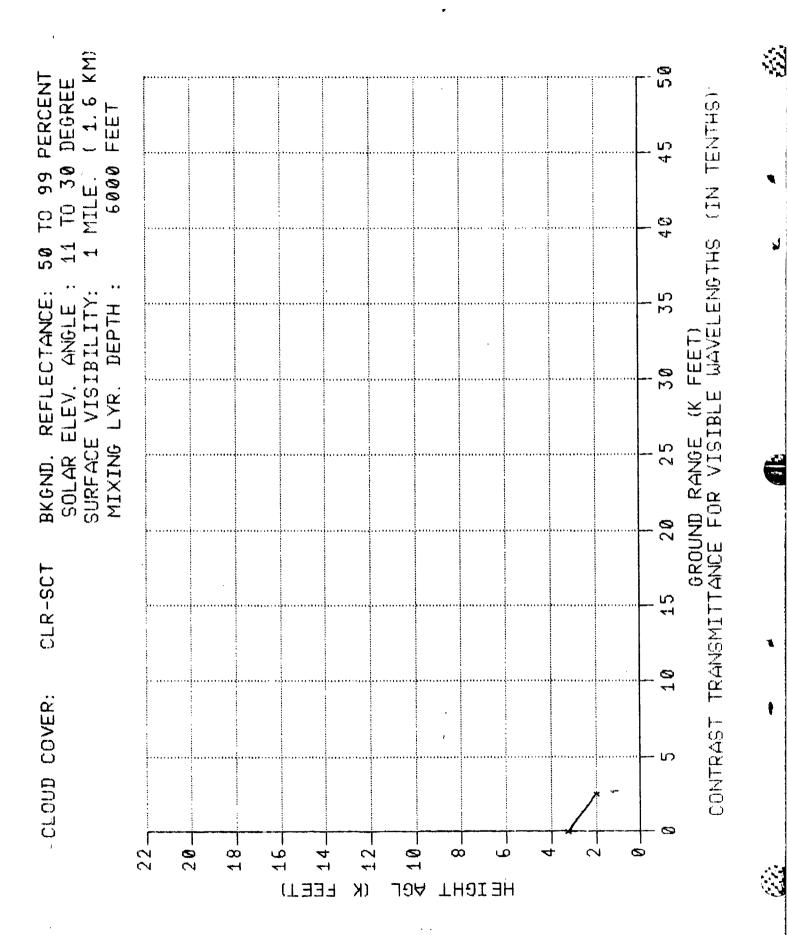
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H-308

GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS)

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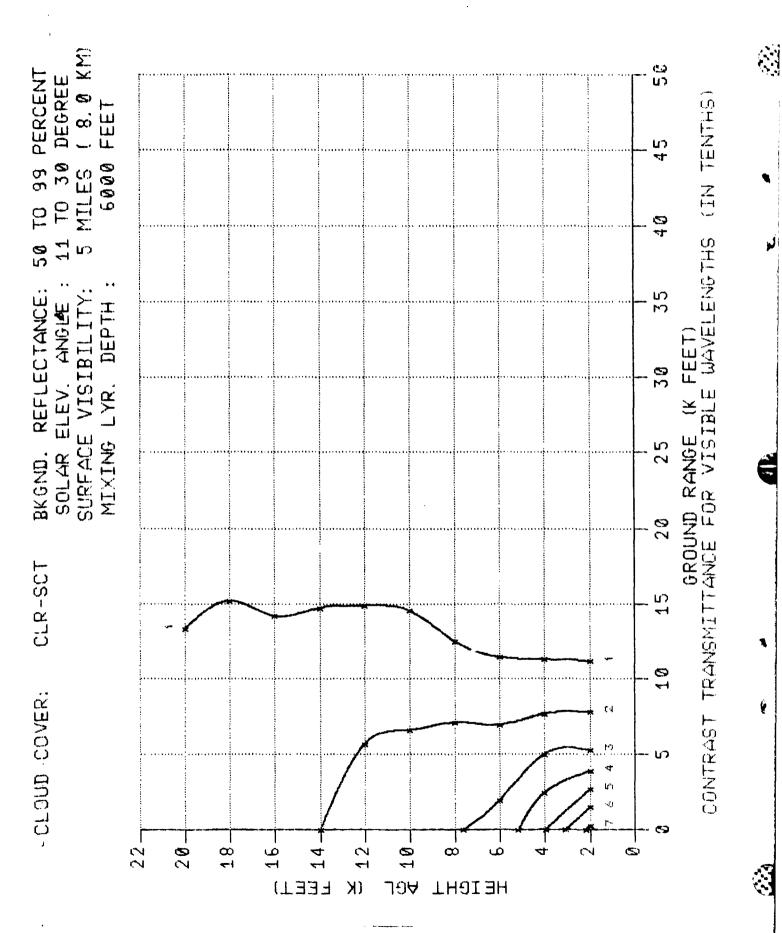
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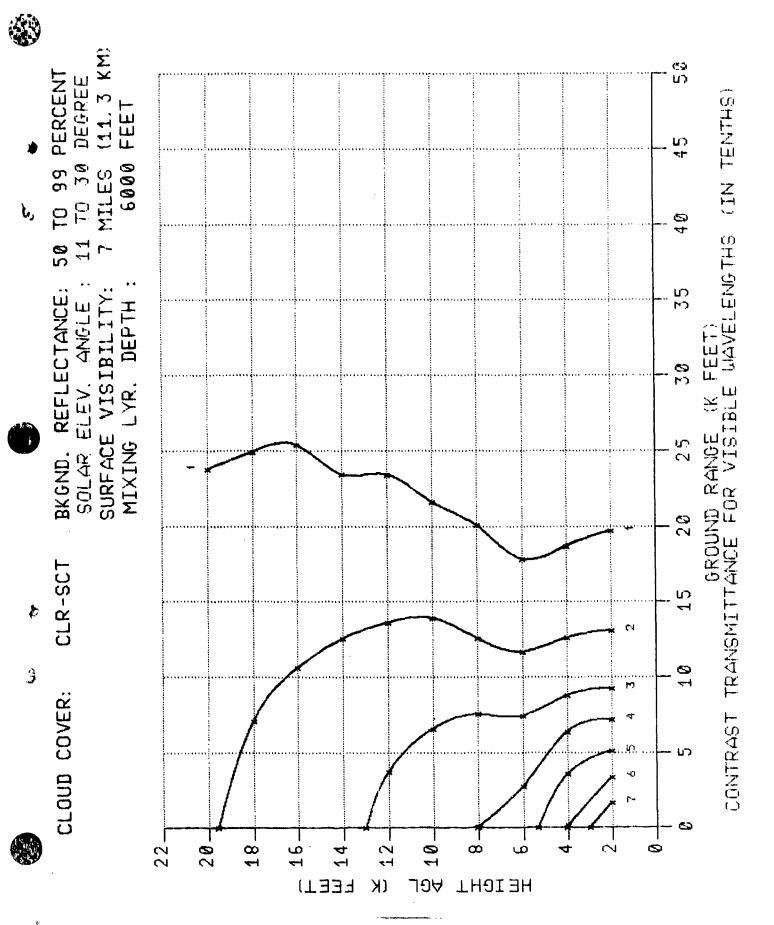
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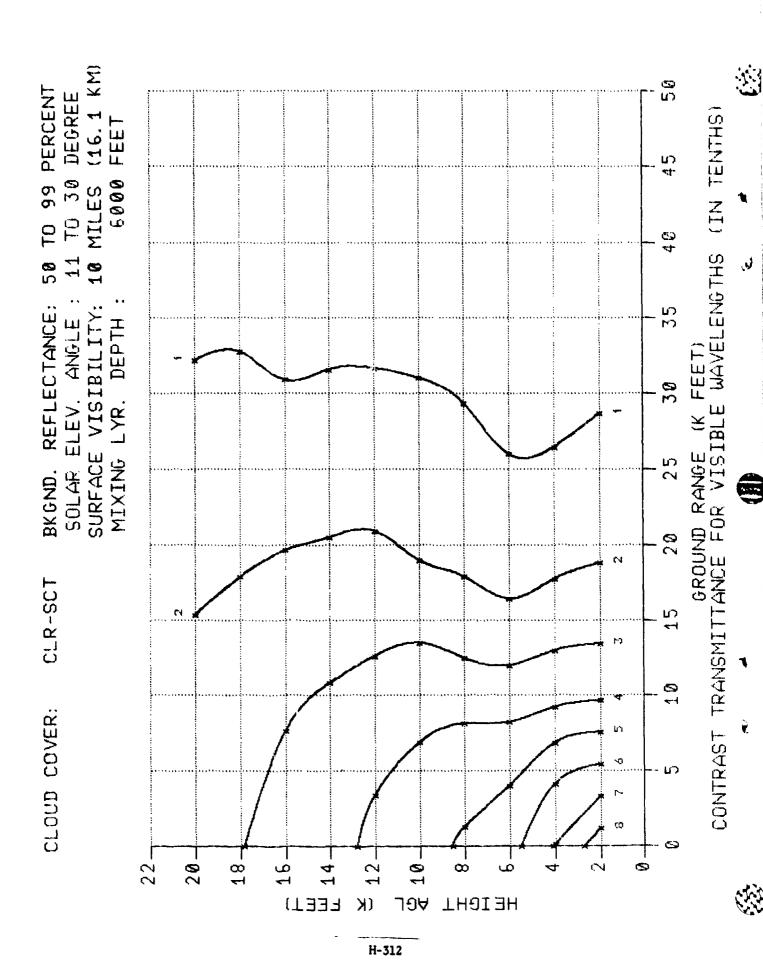
H-310

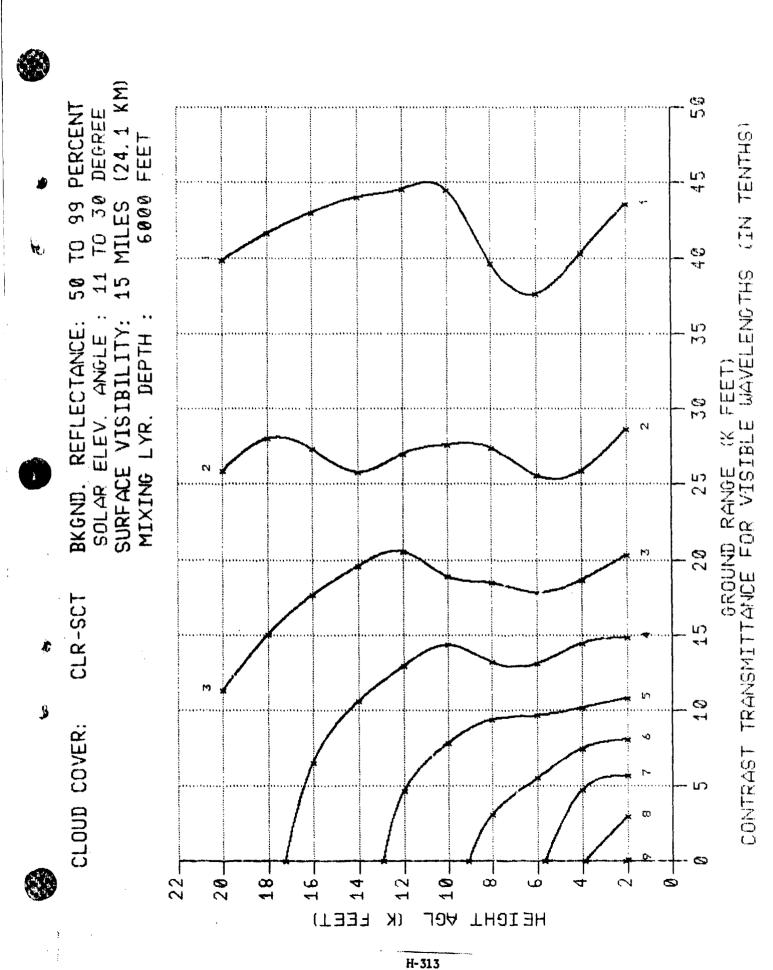


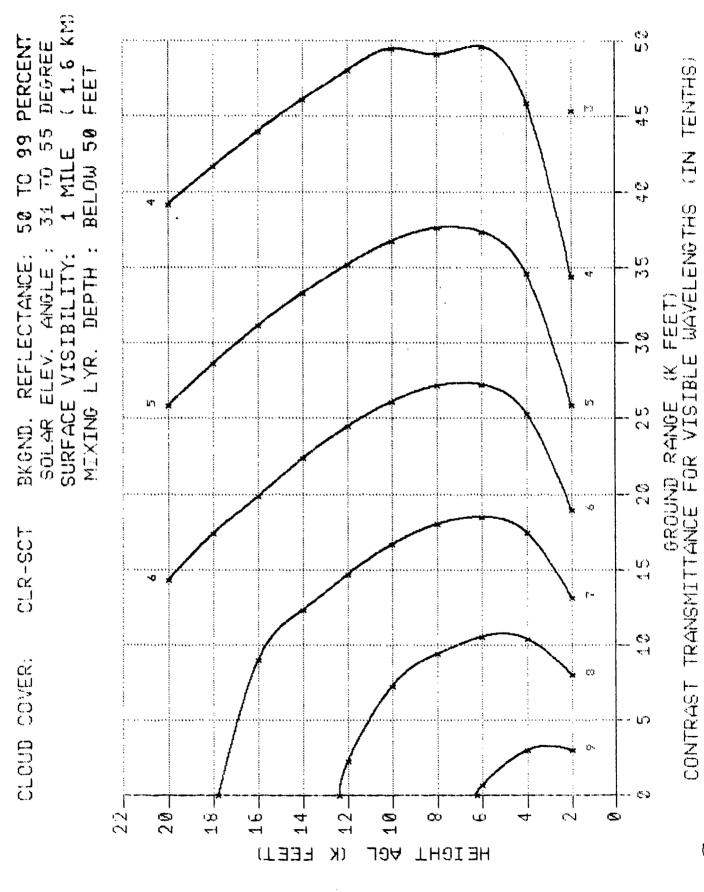
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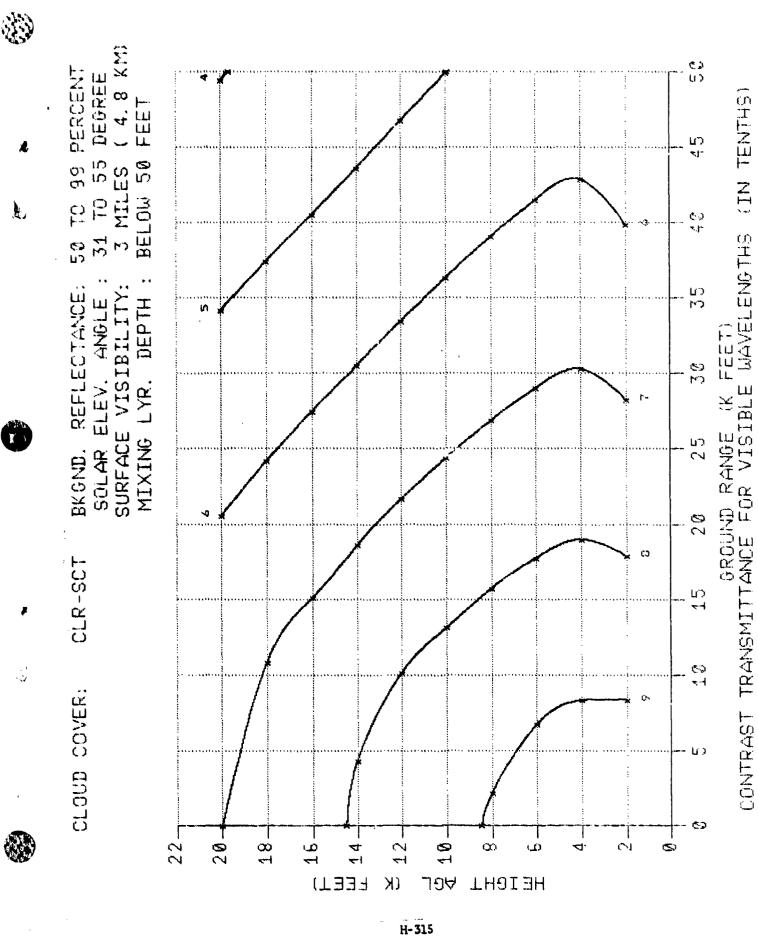






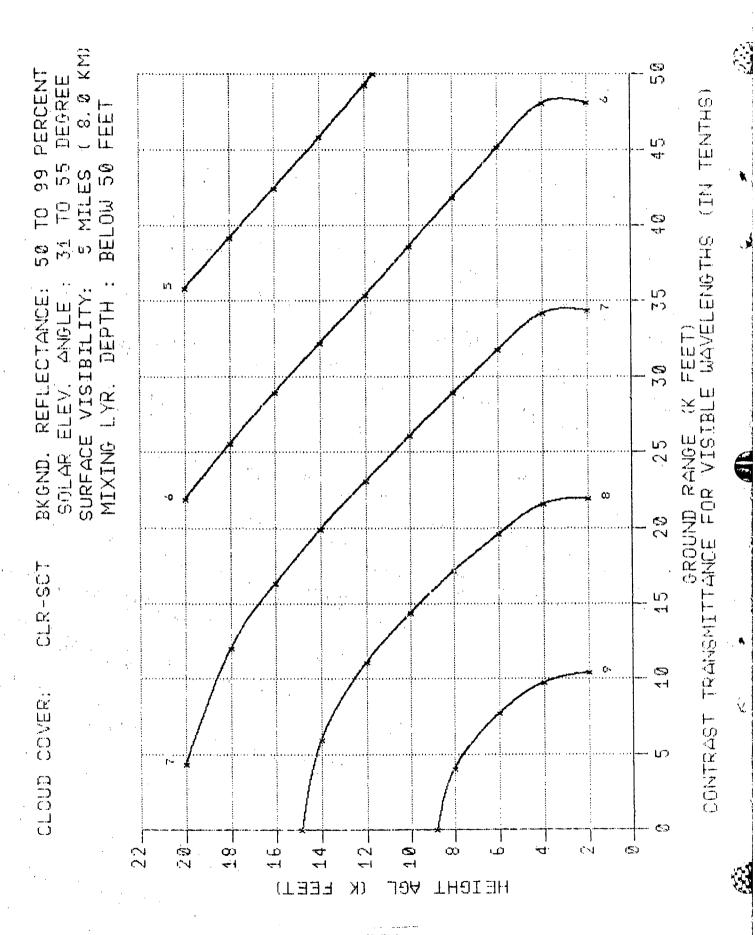
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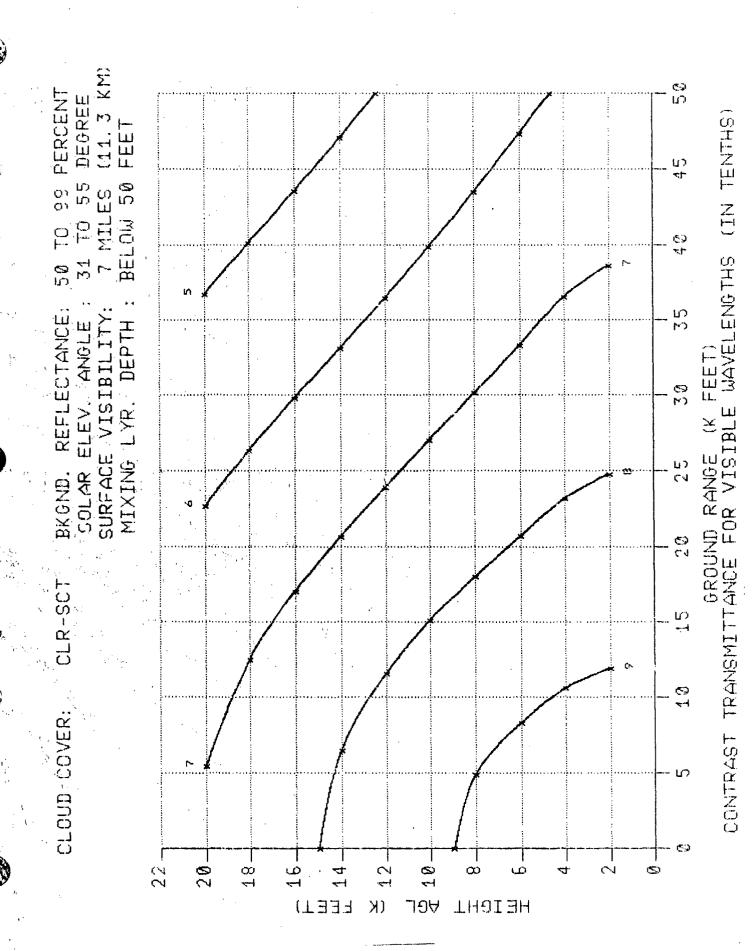


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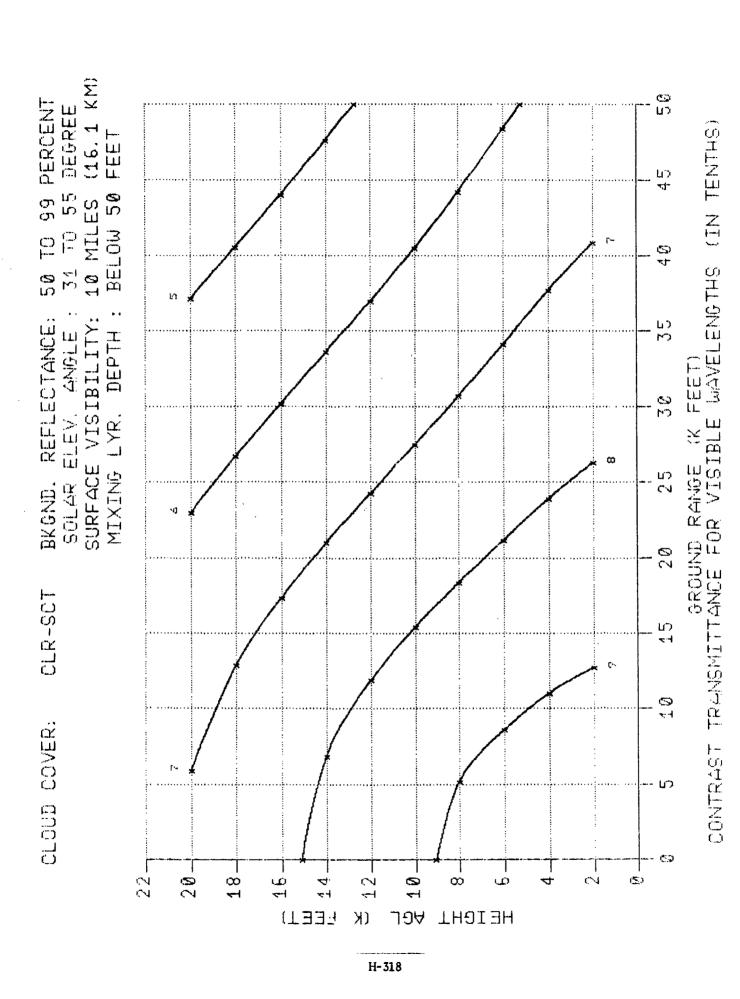
H-316



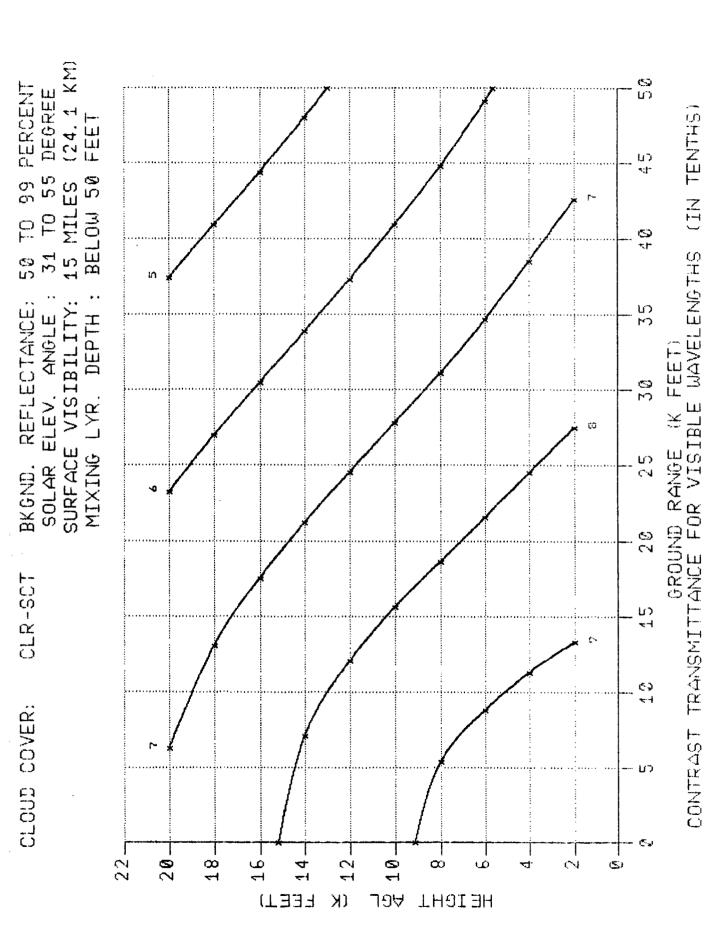
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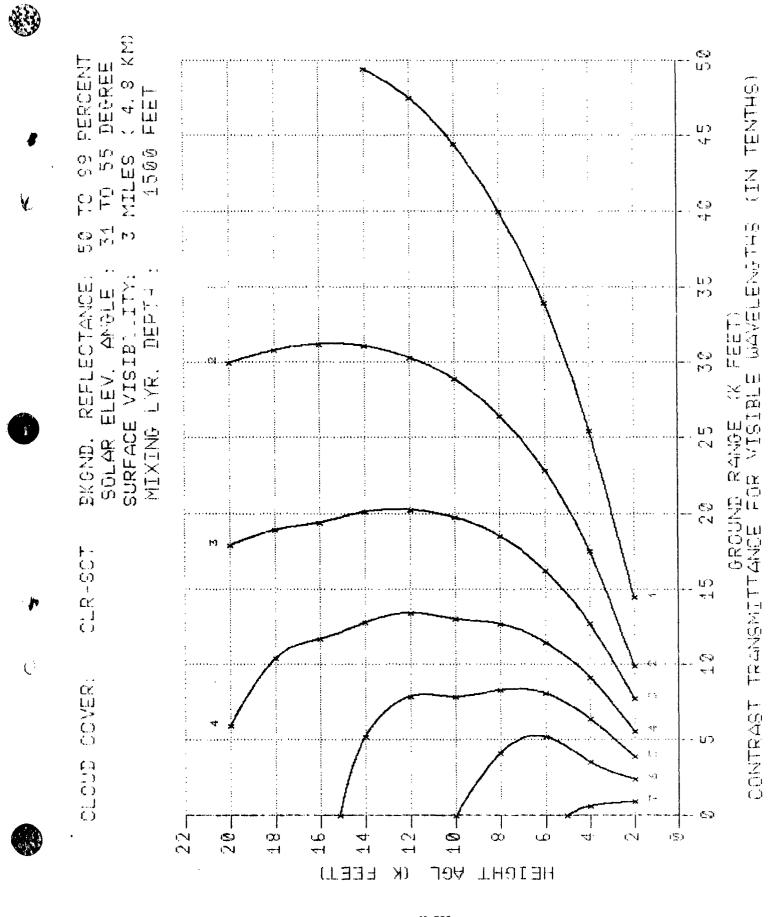


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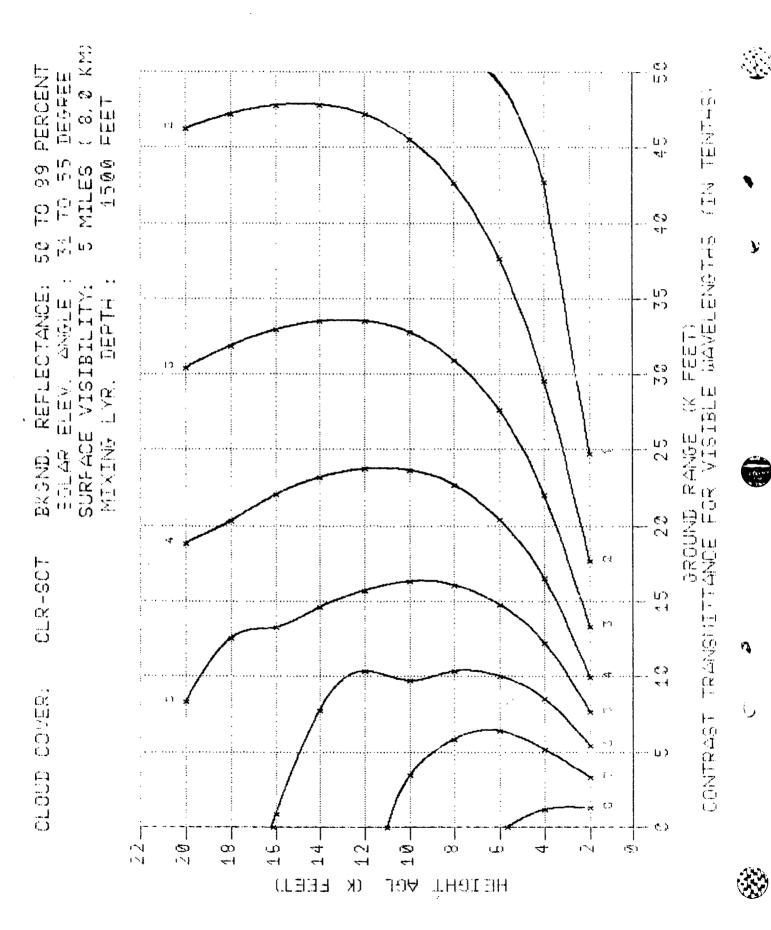


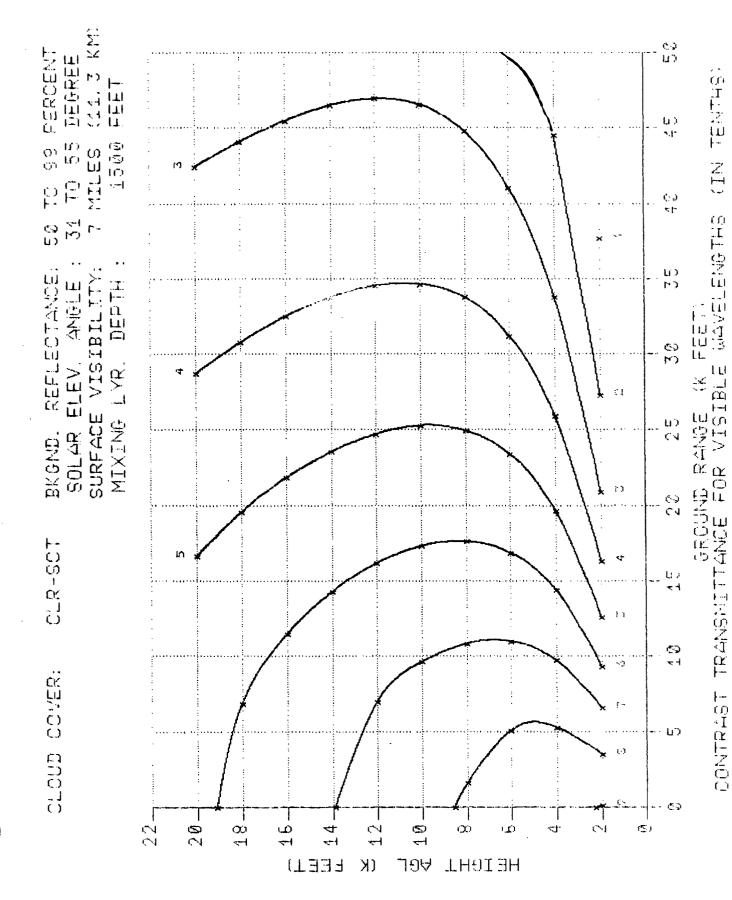
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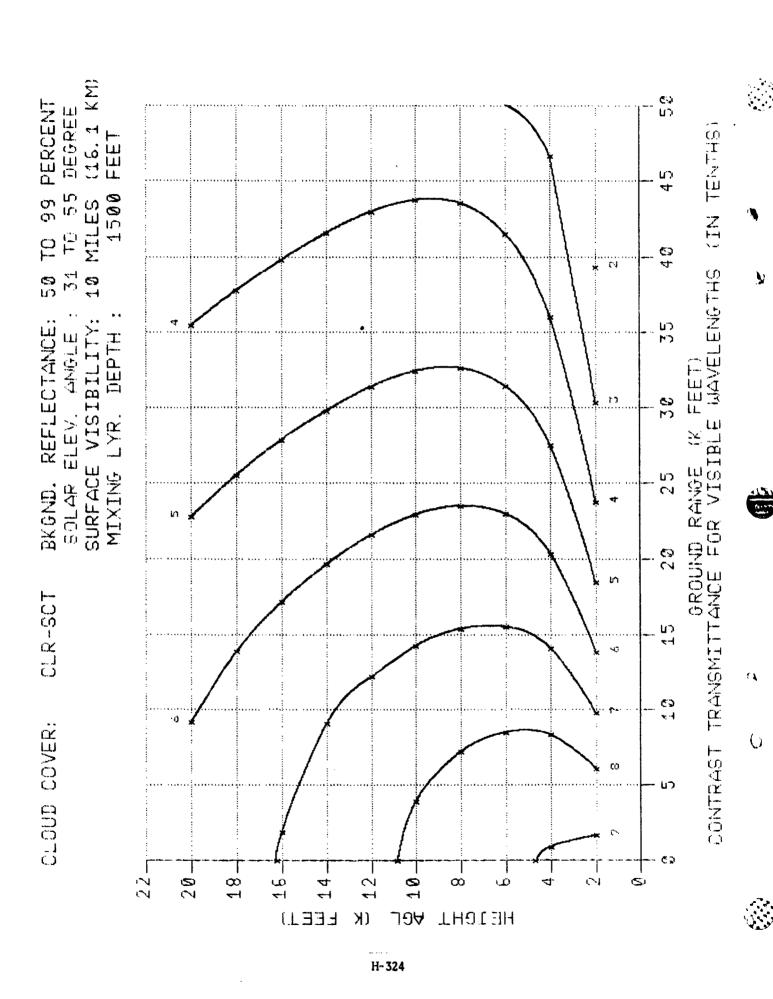


H-321

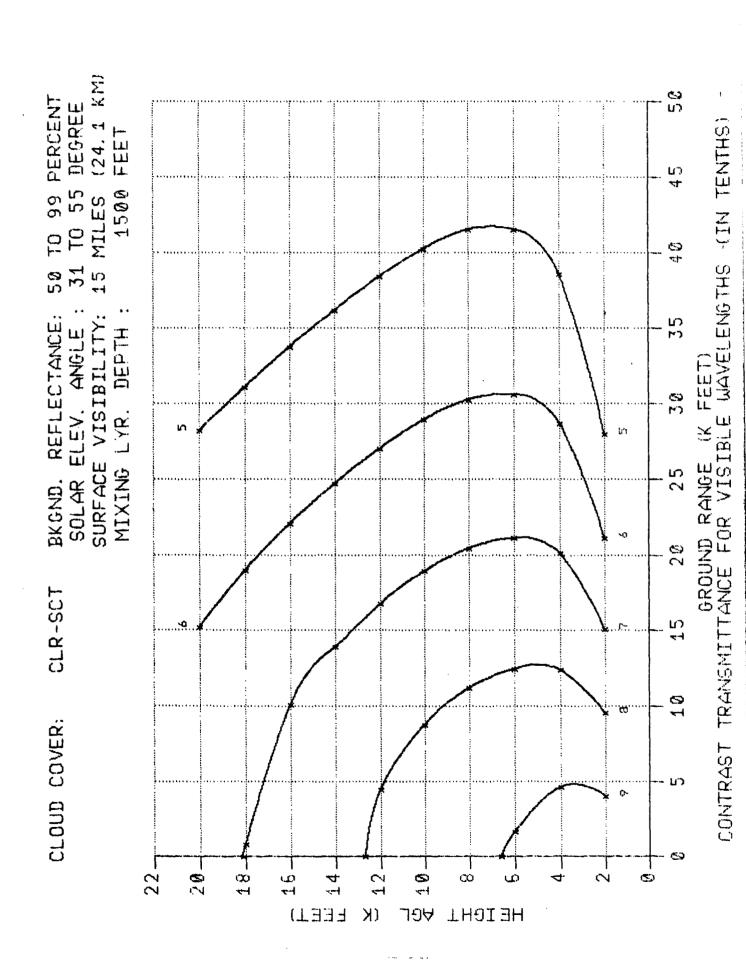




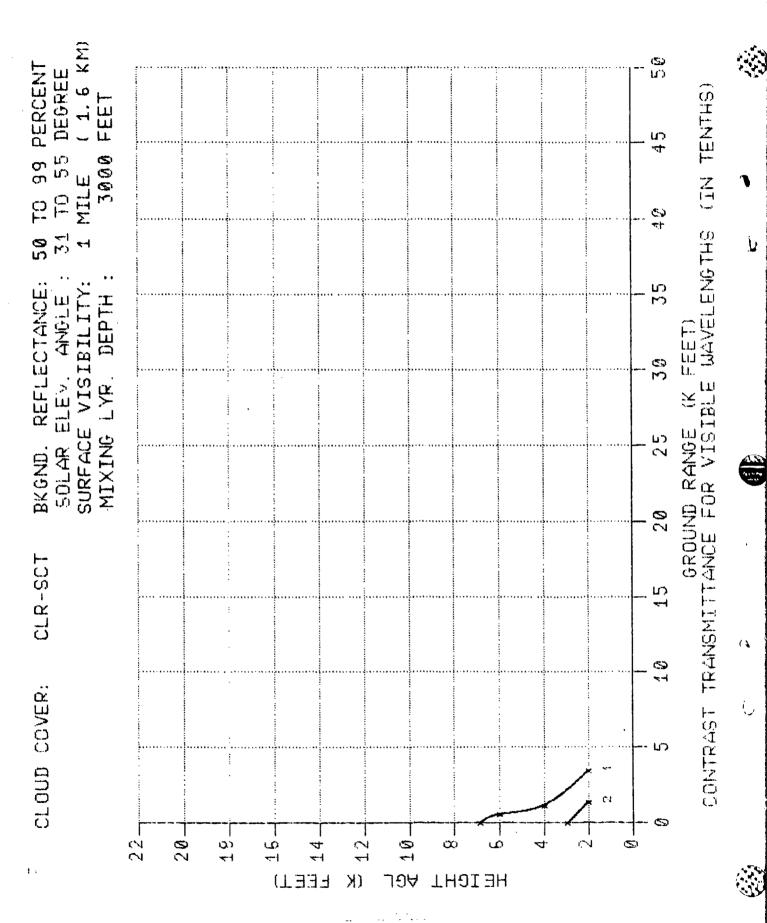
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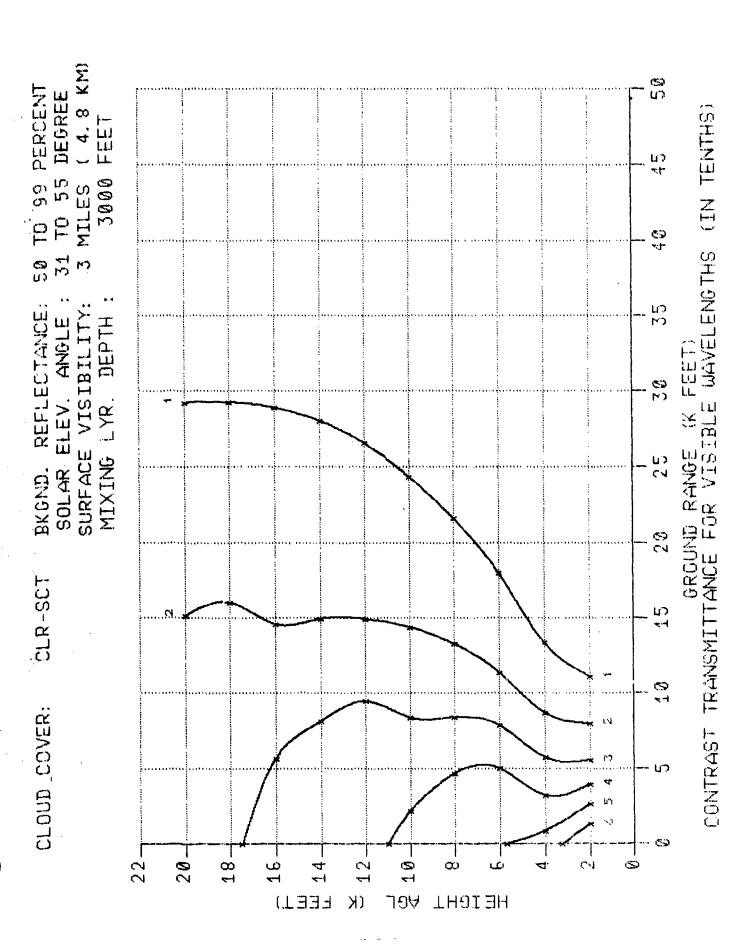
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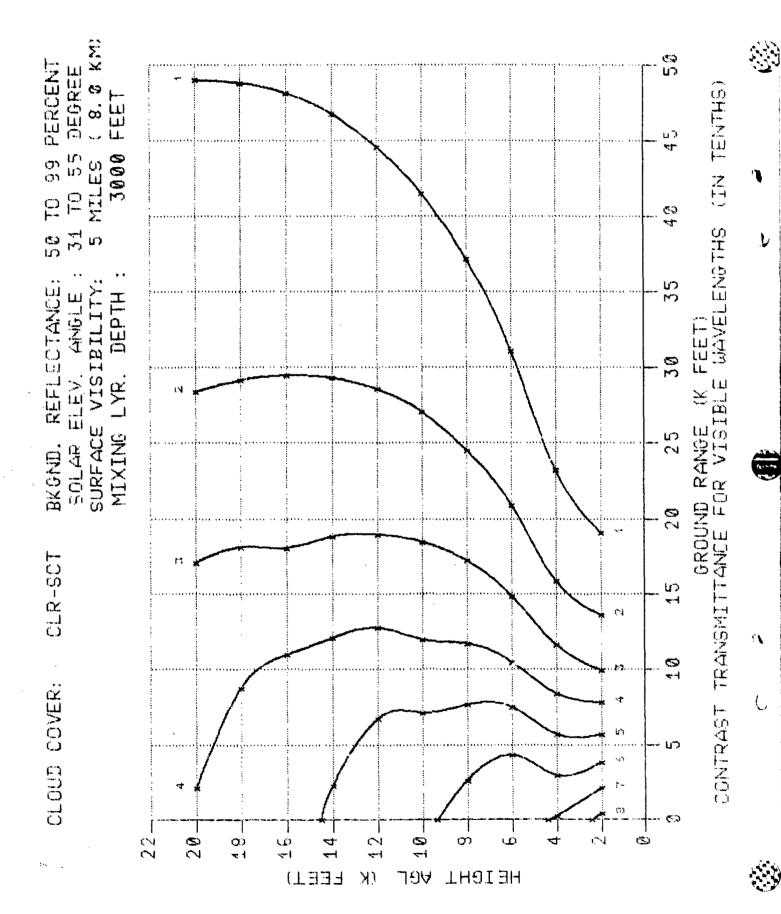
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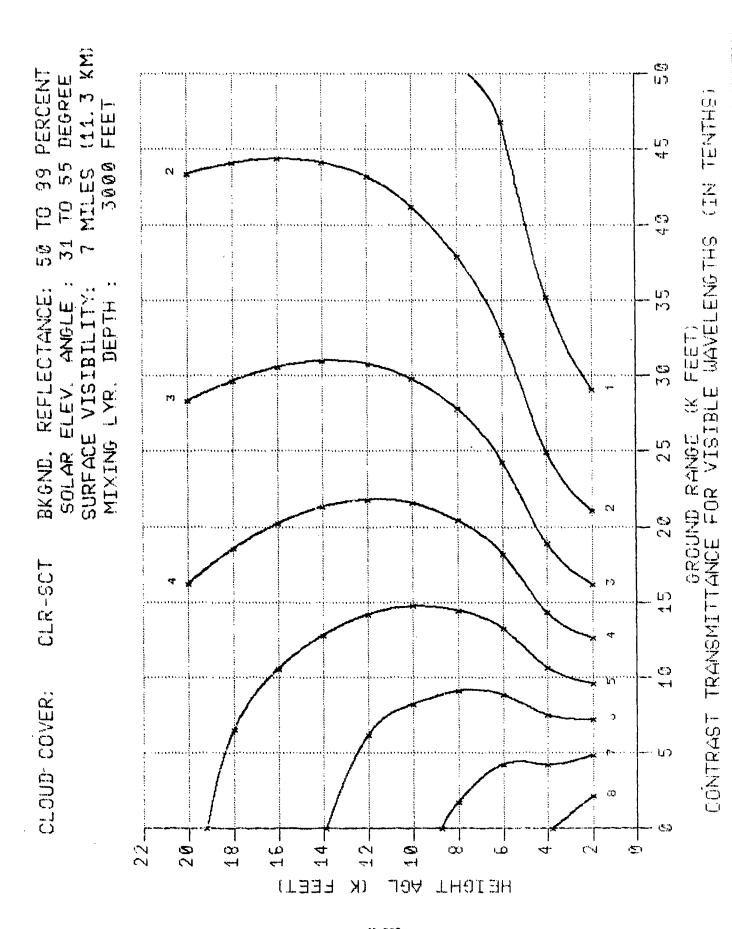


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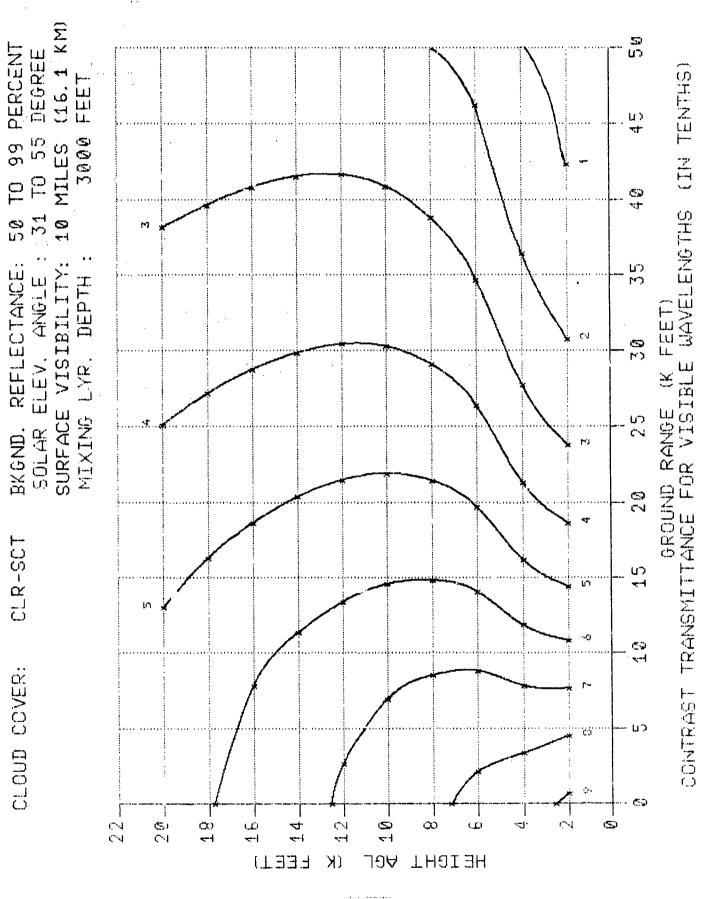
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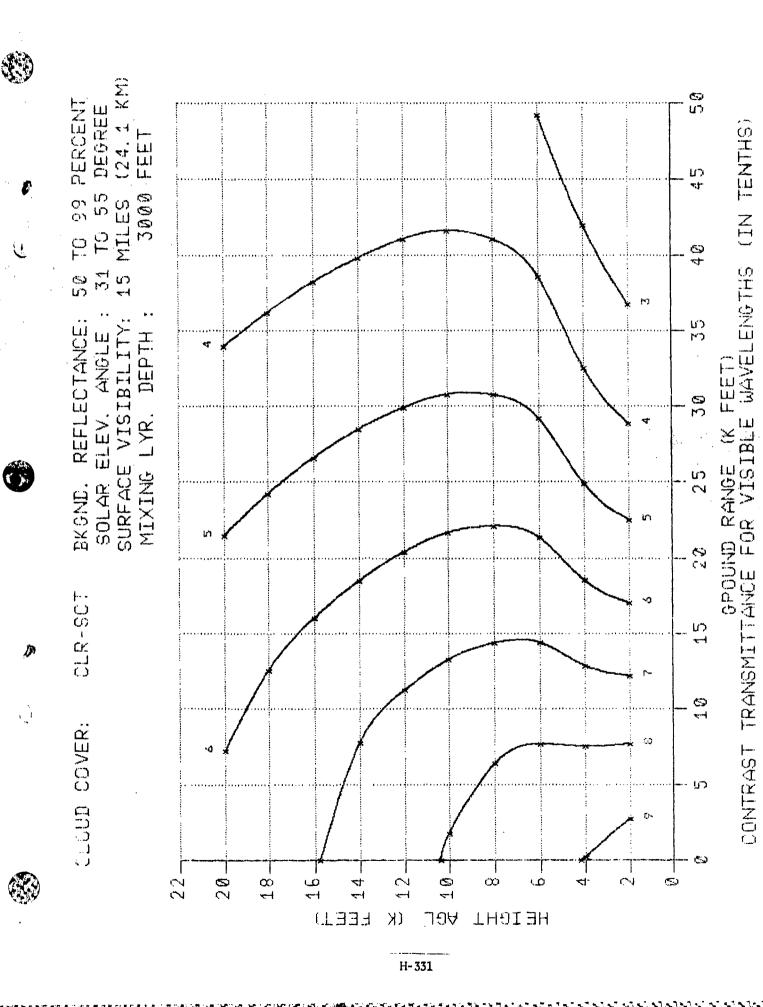


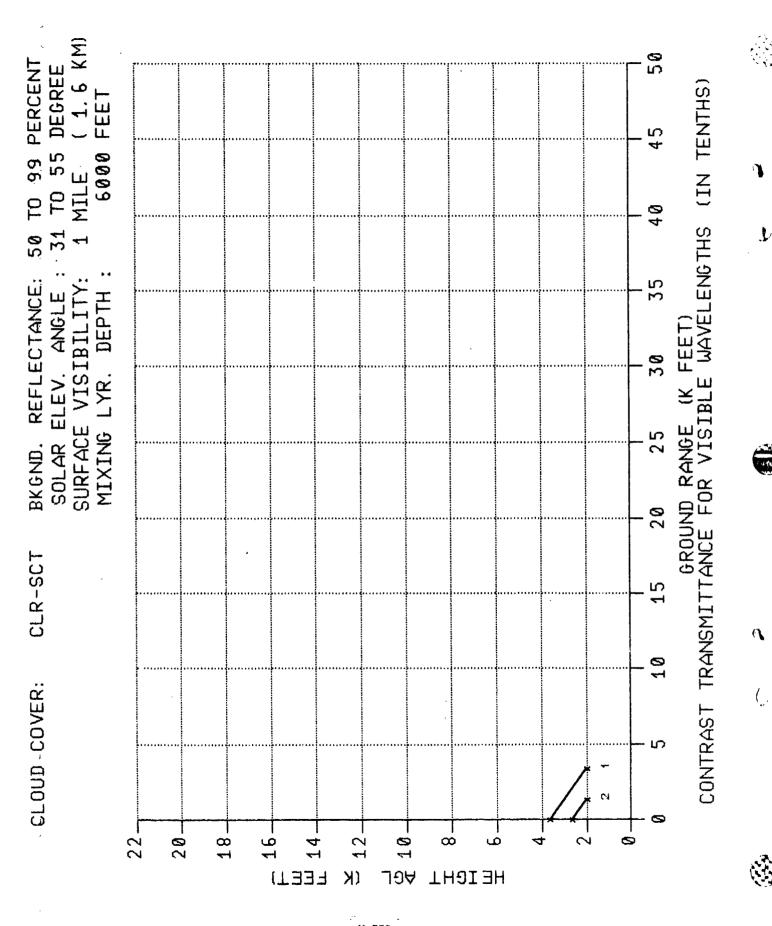
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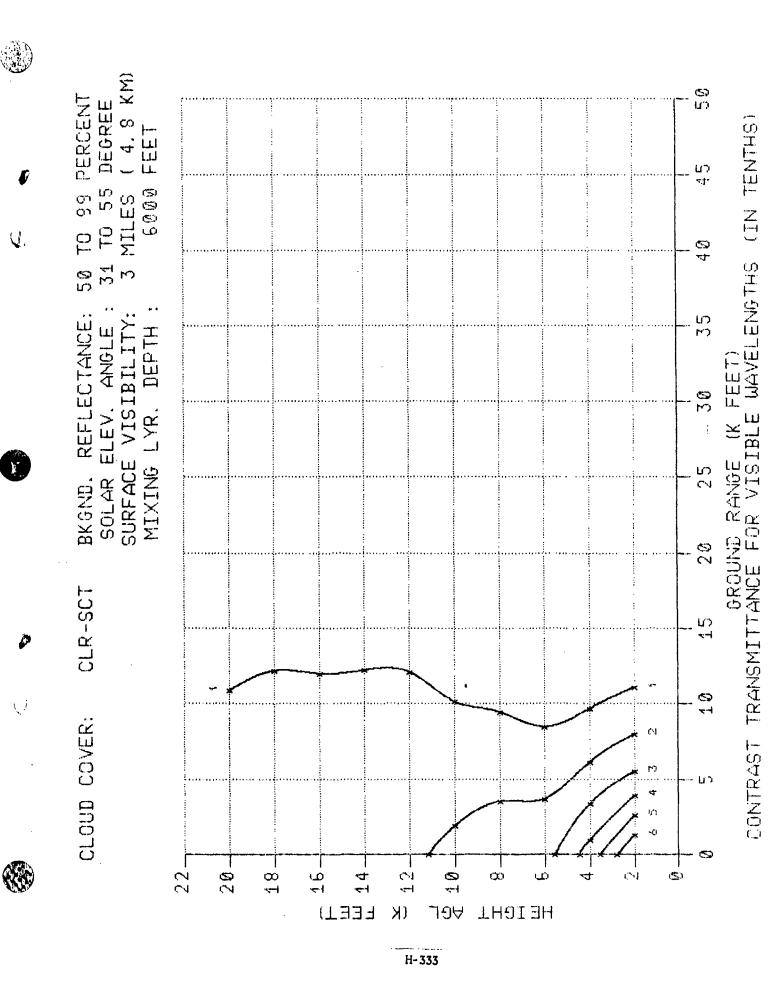
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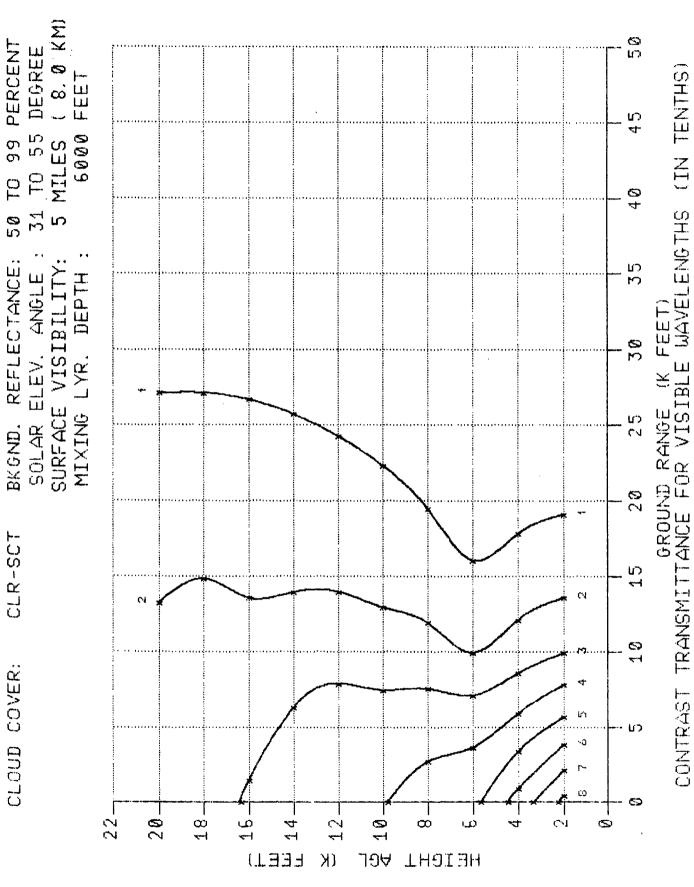


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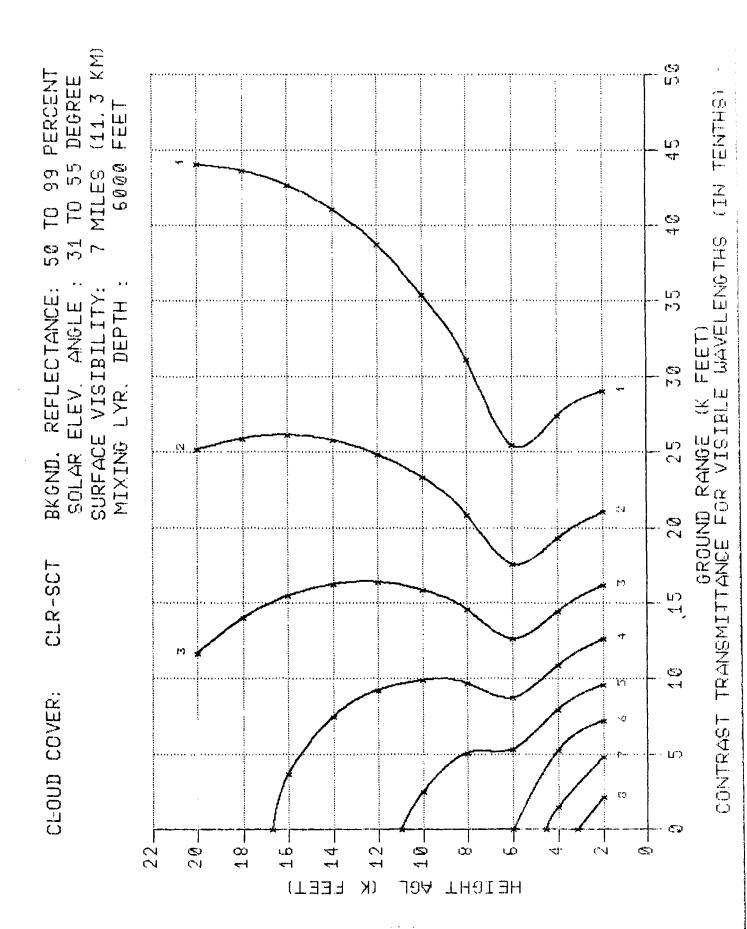








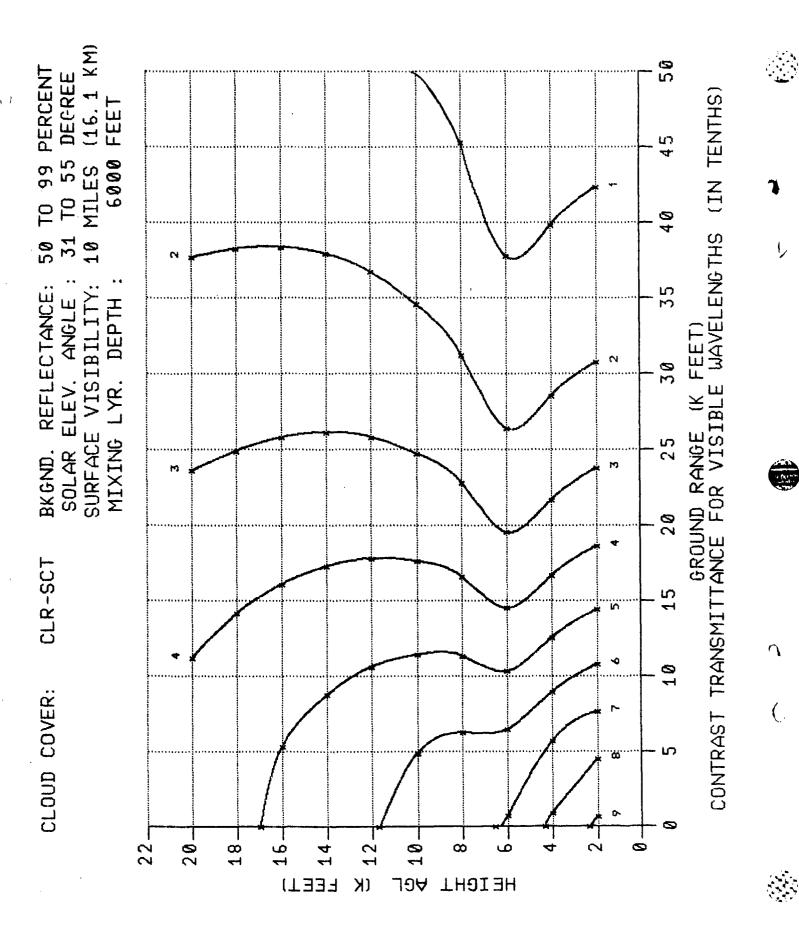
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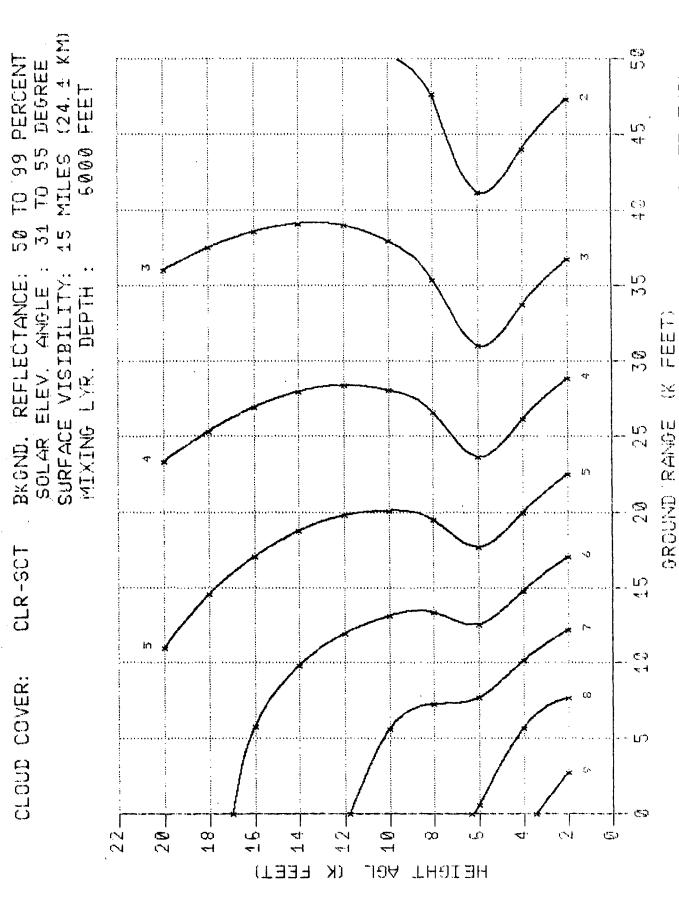


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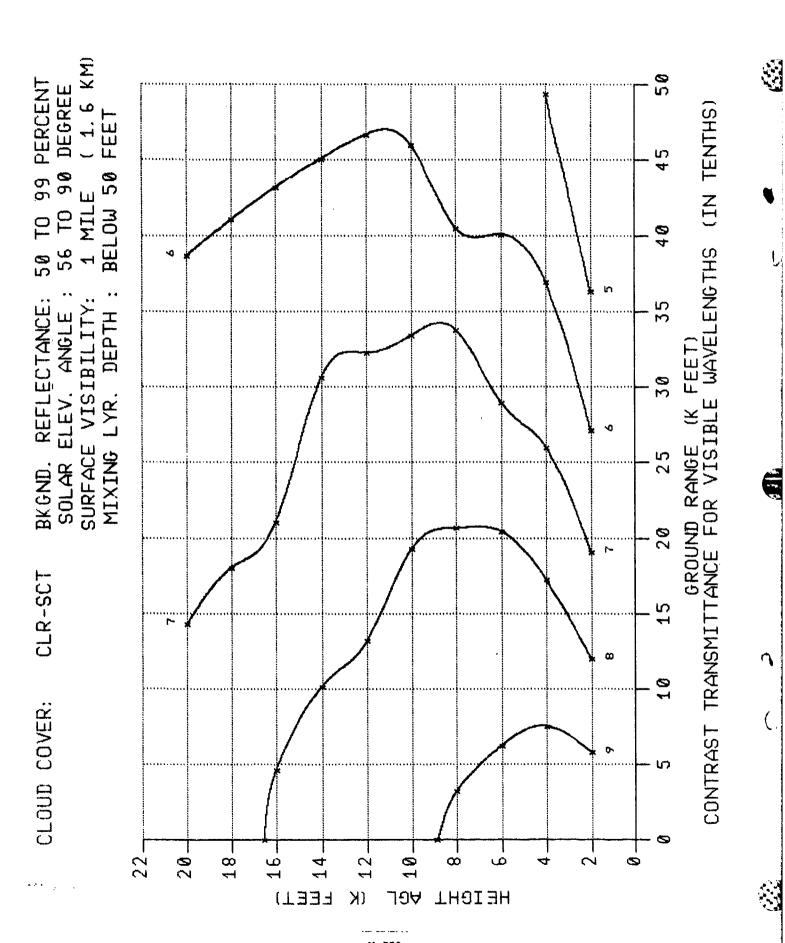
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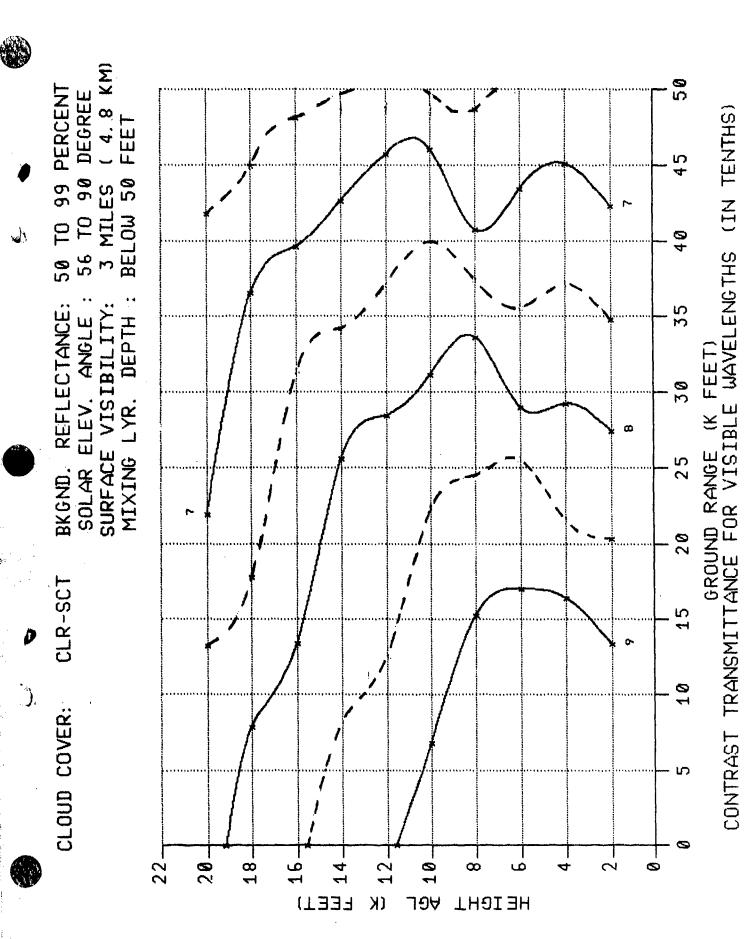


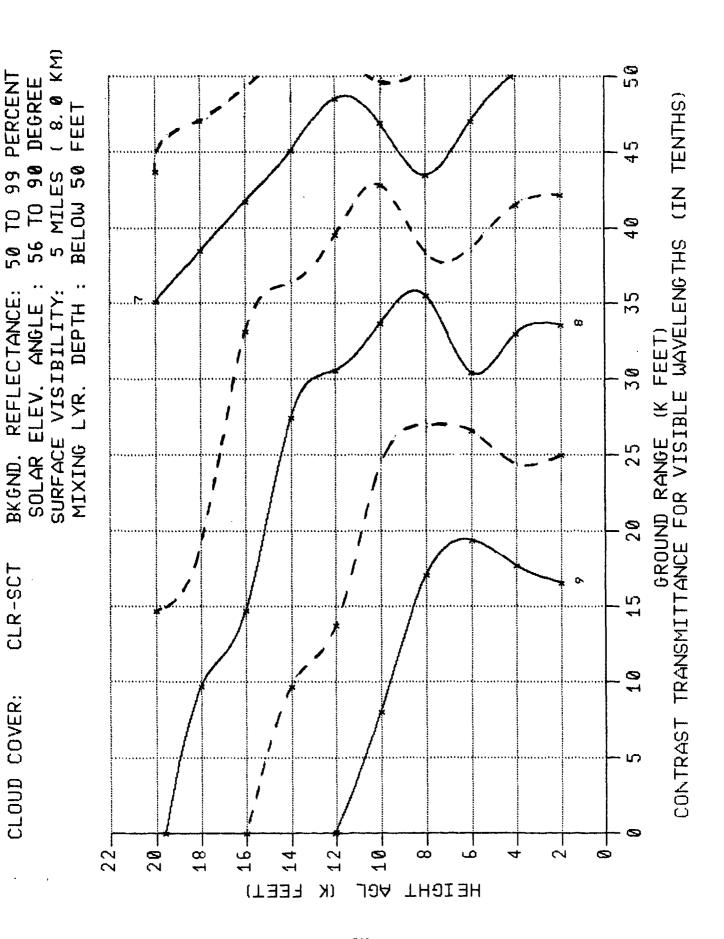


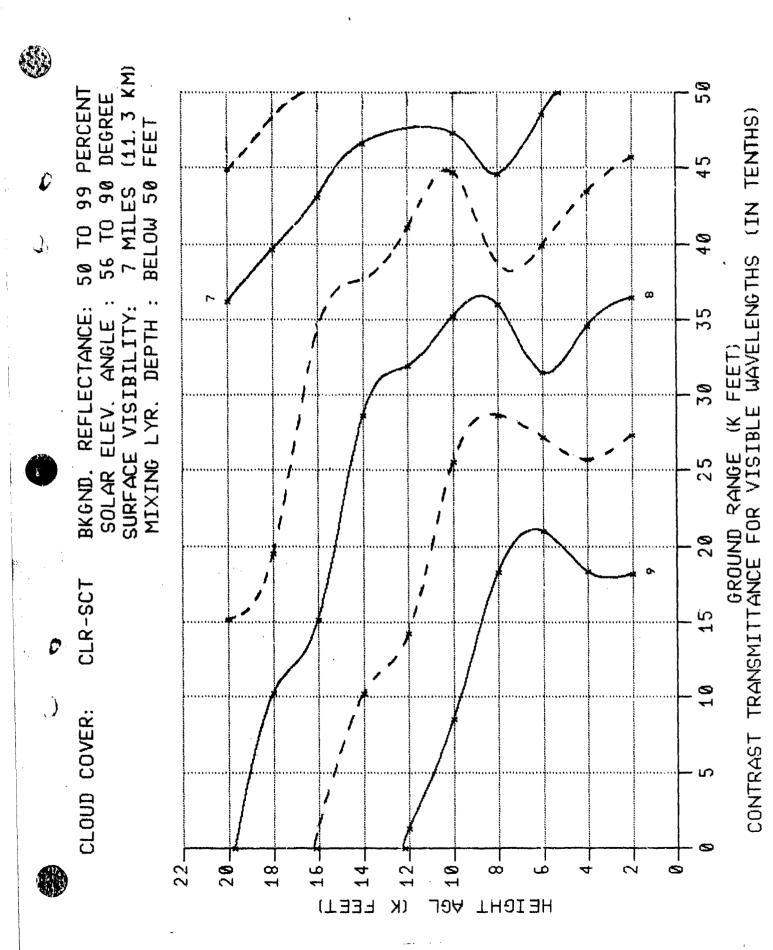
UNIVELENGTHS (IN TENTHS) CONTRAST TRANSMITTANCE FOR VISIBLE

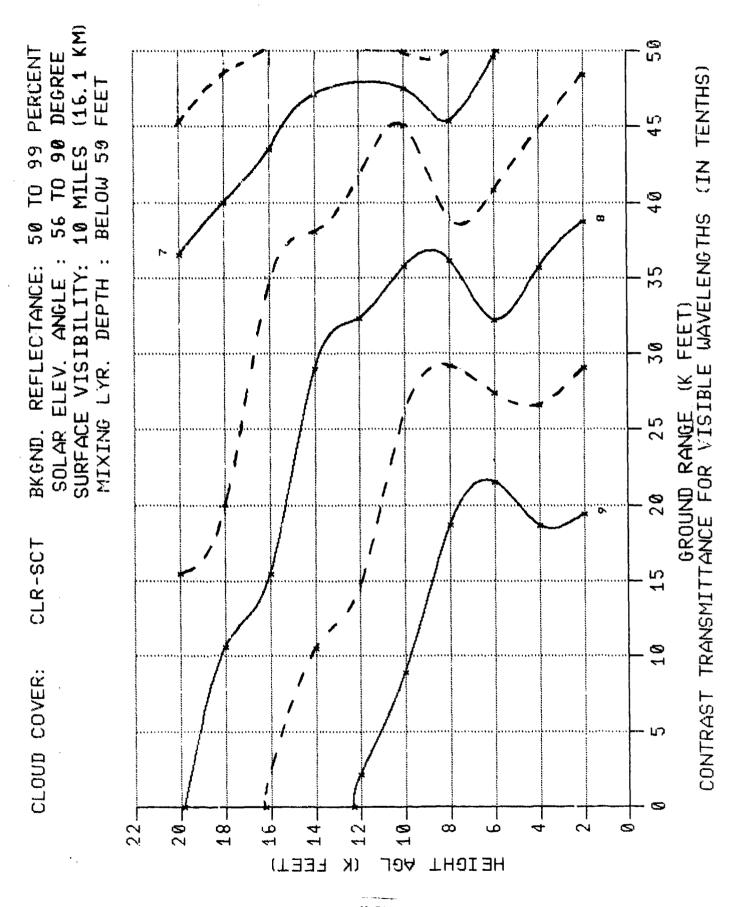


H-338

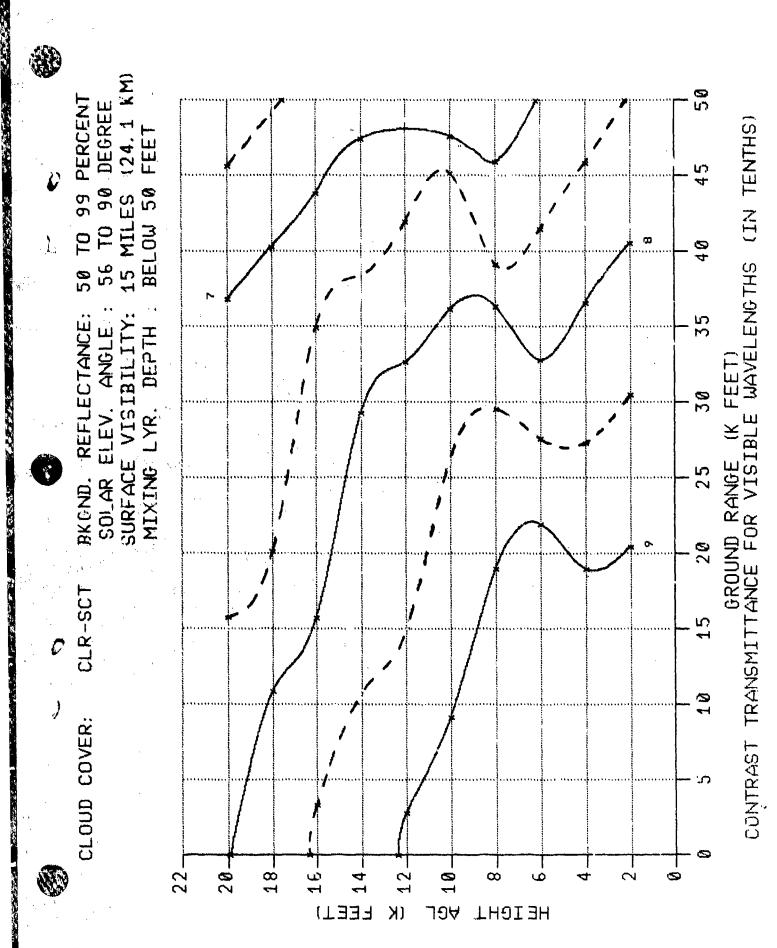


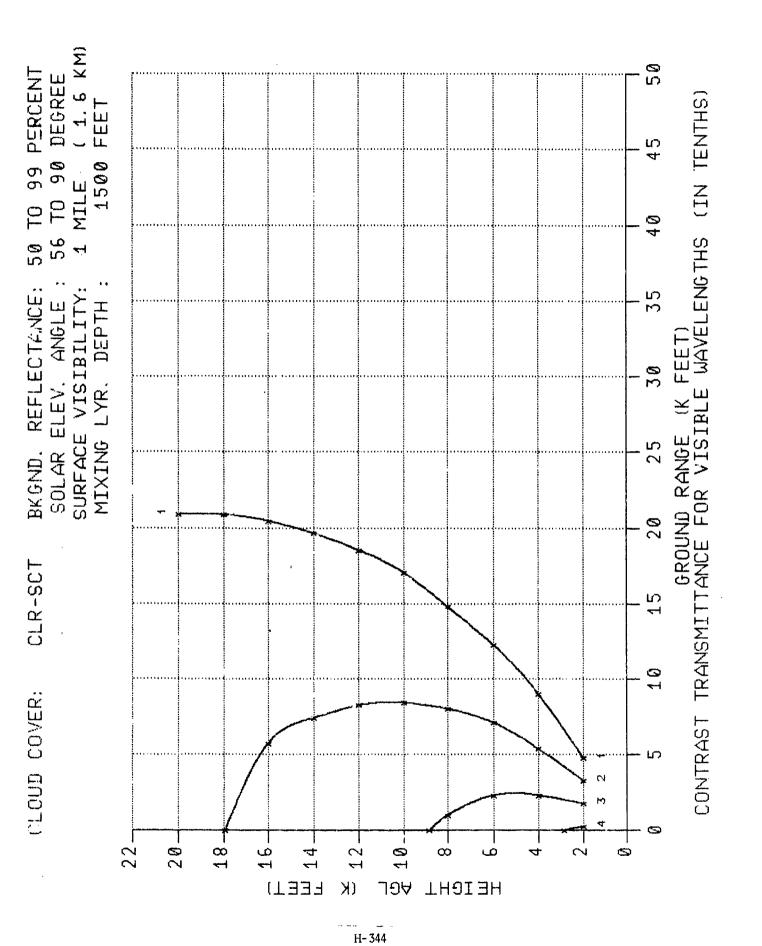




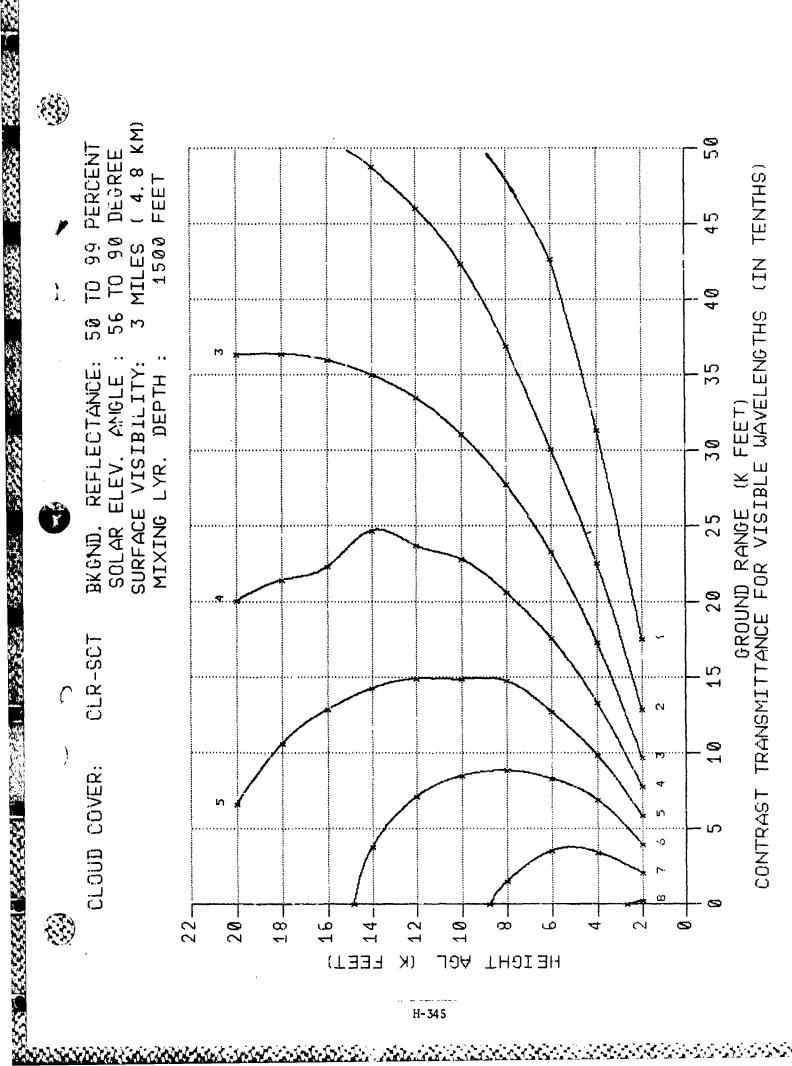


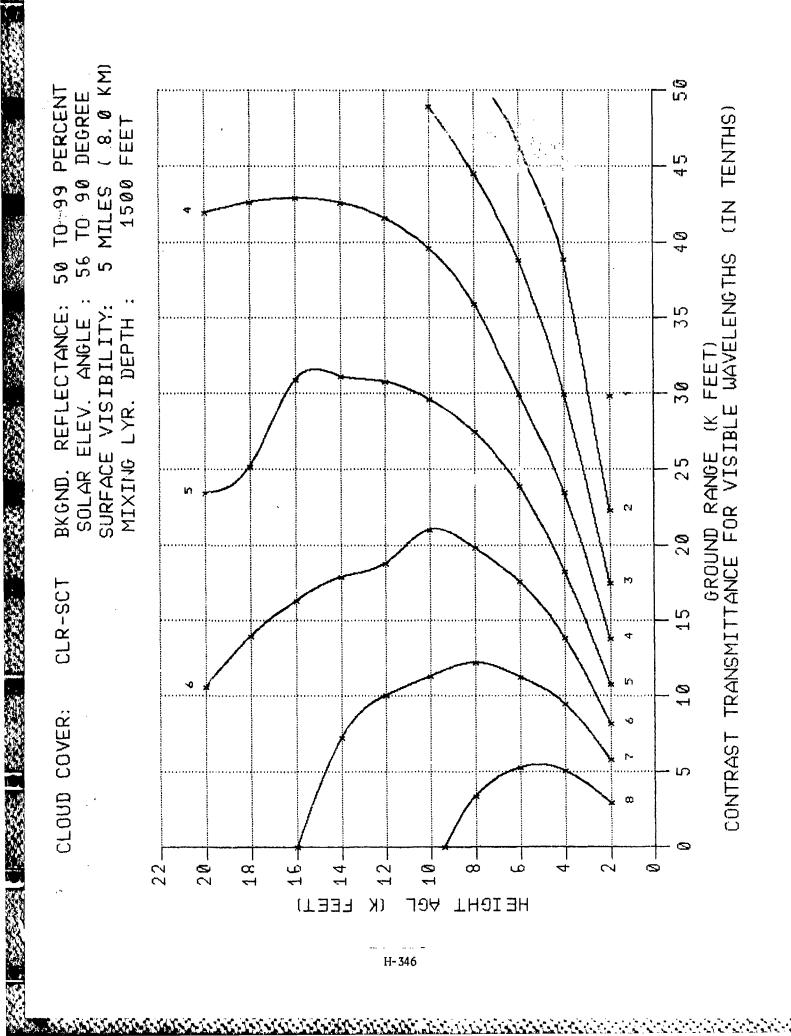
H-342

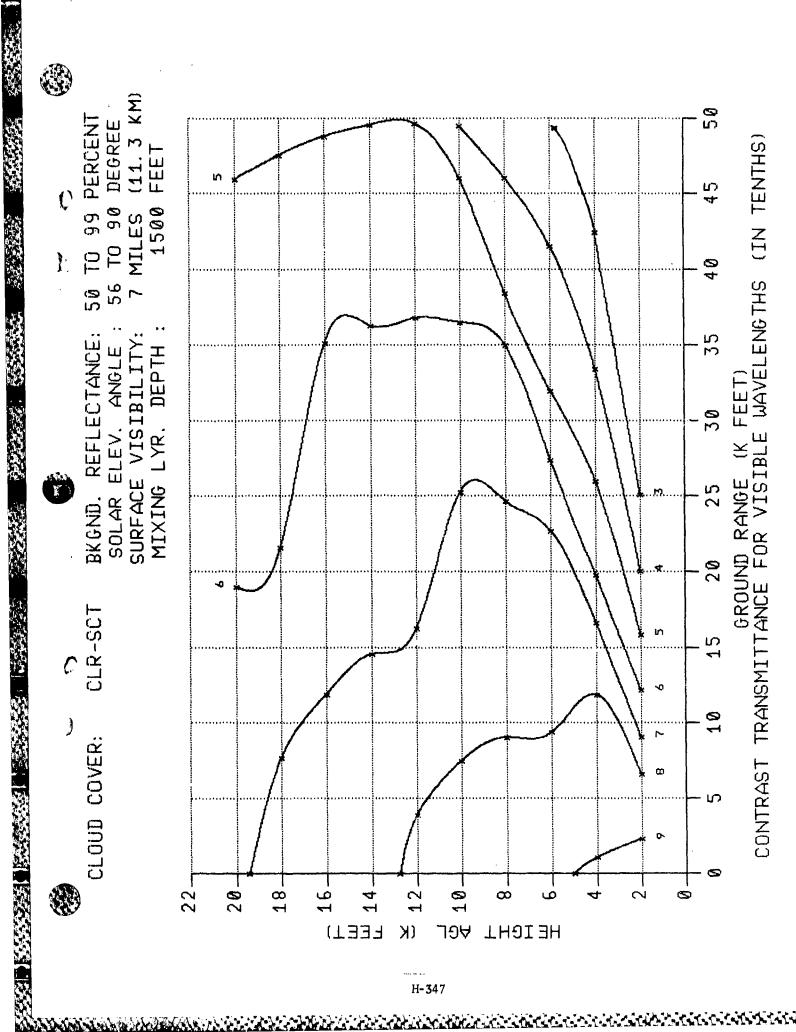


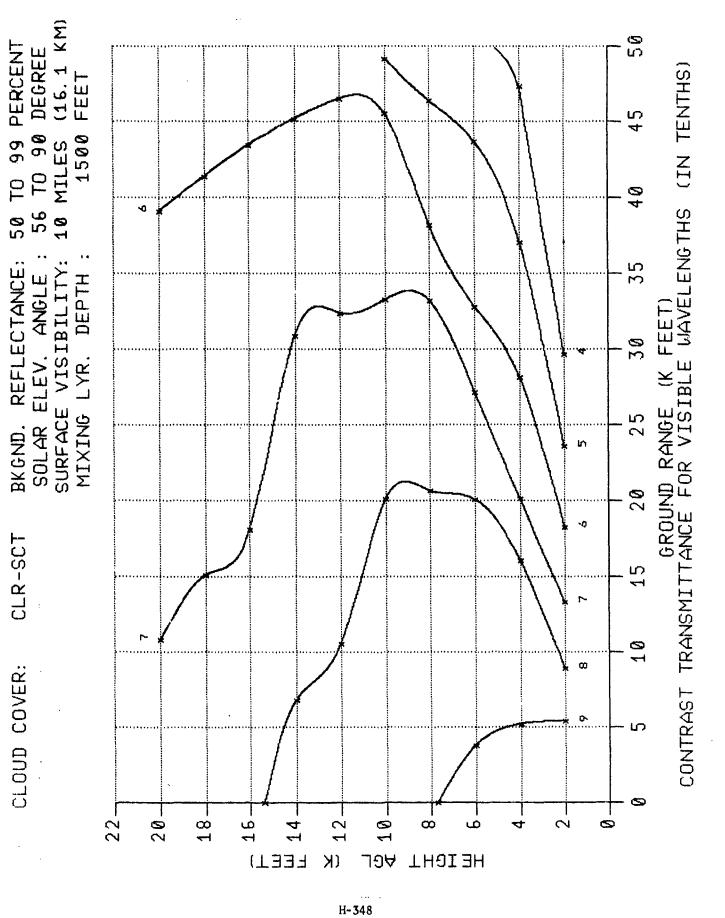


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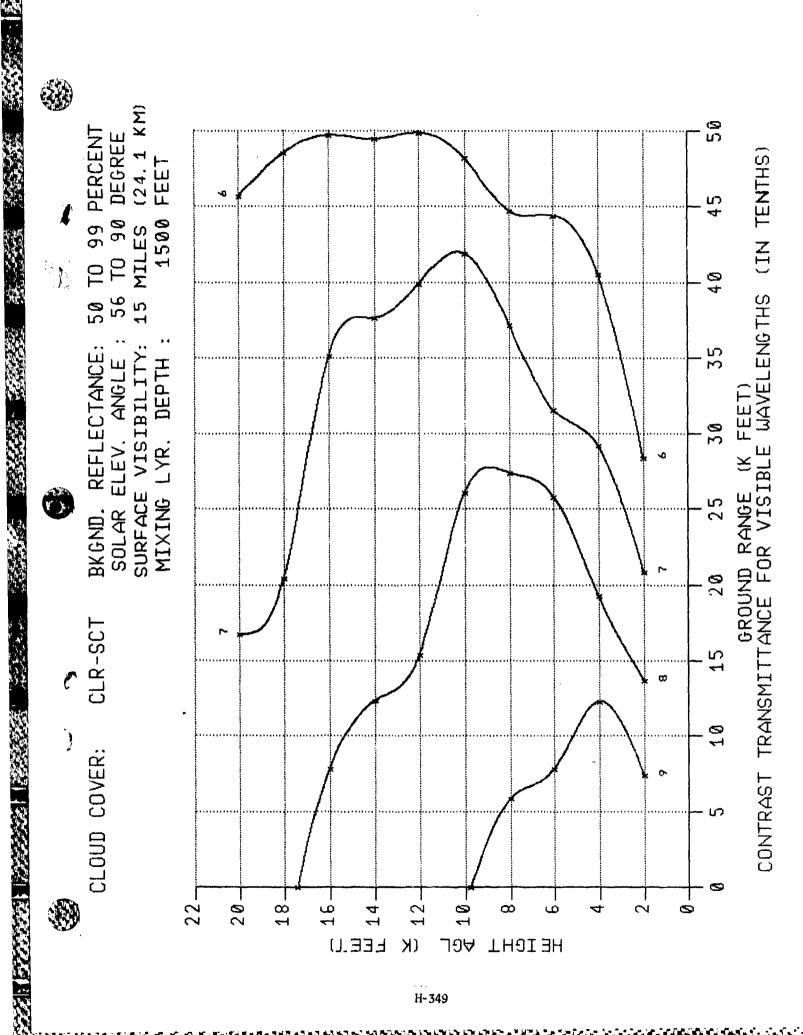


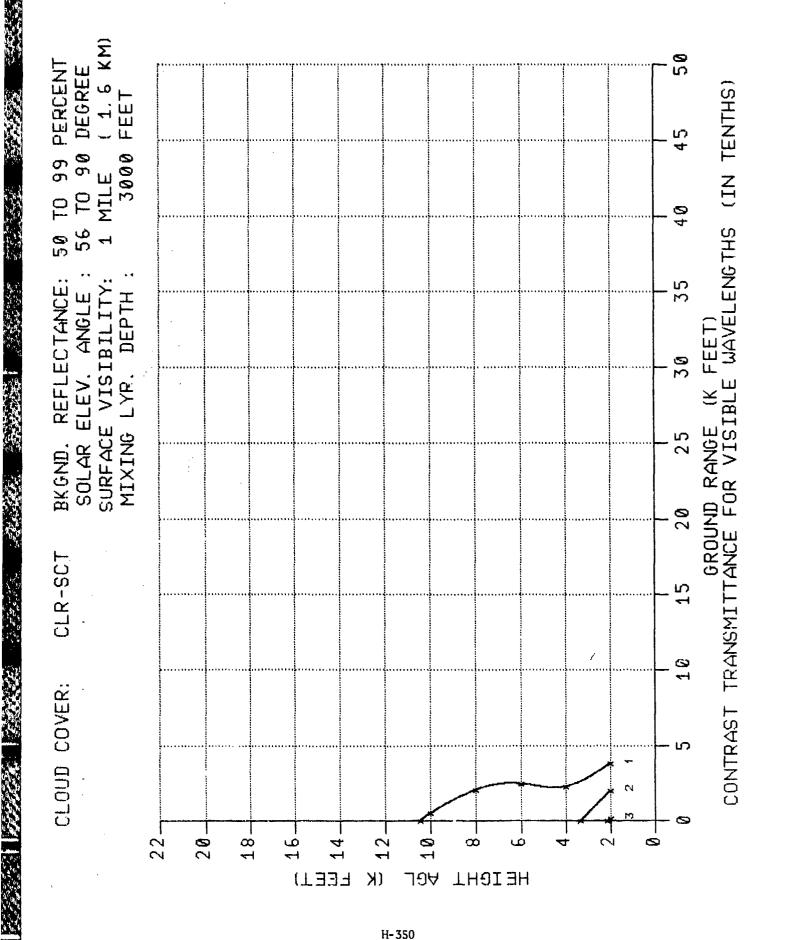


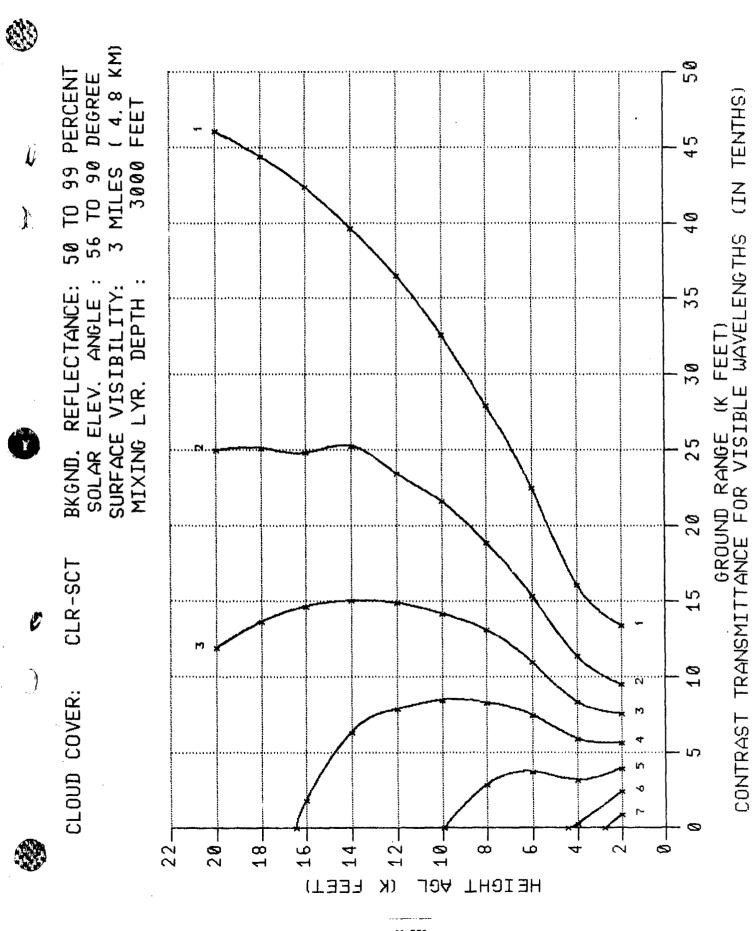




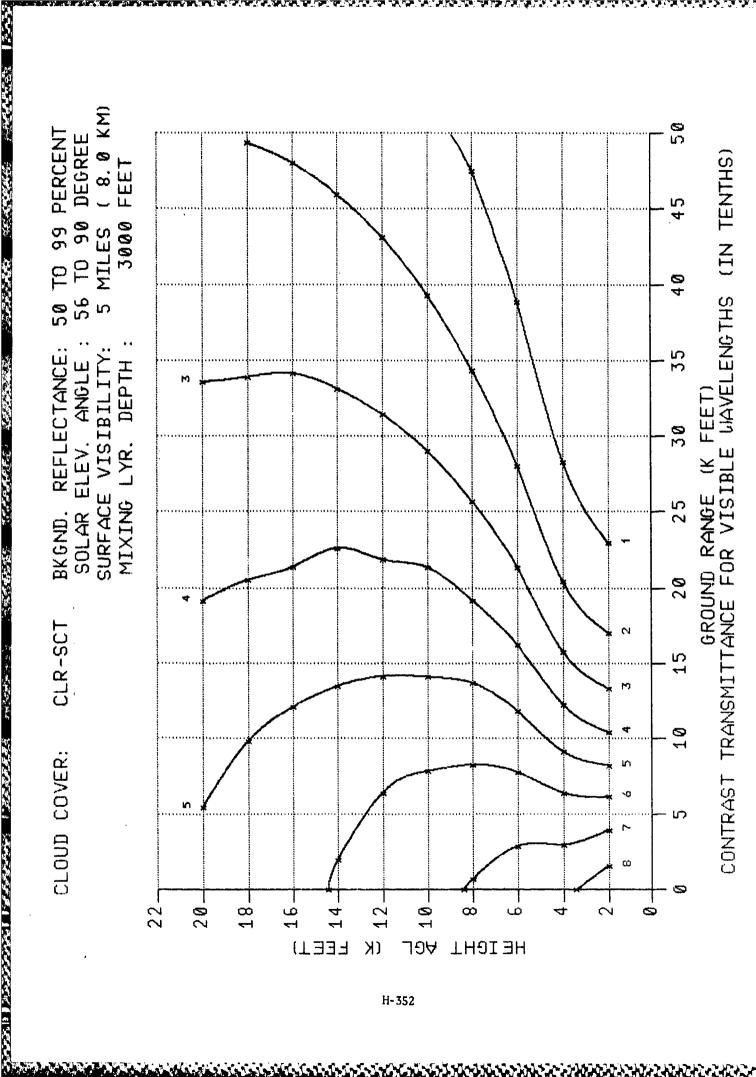
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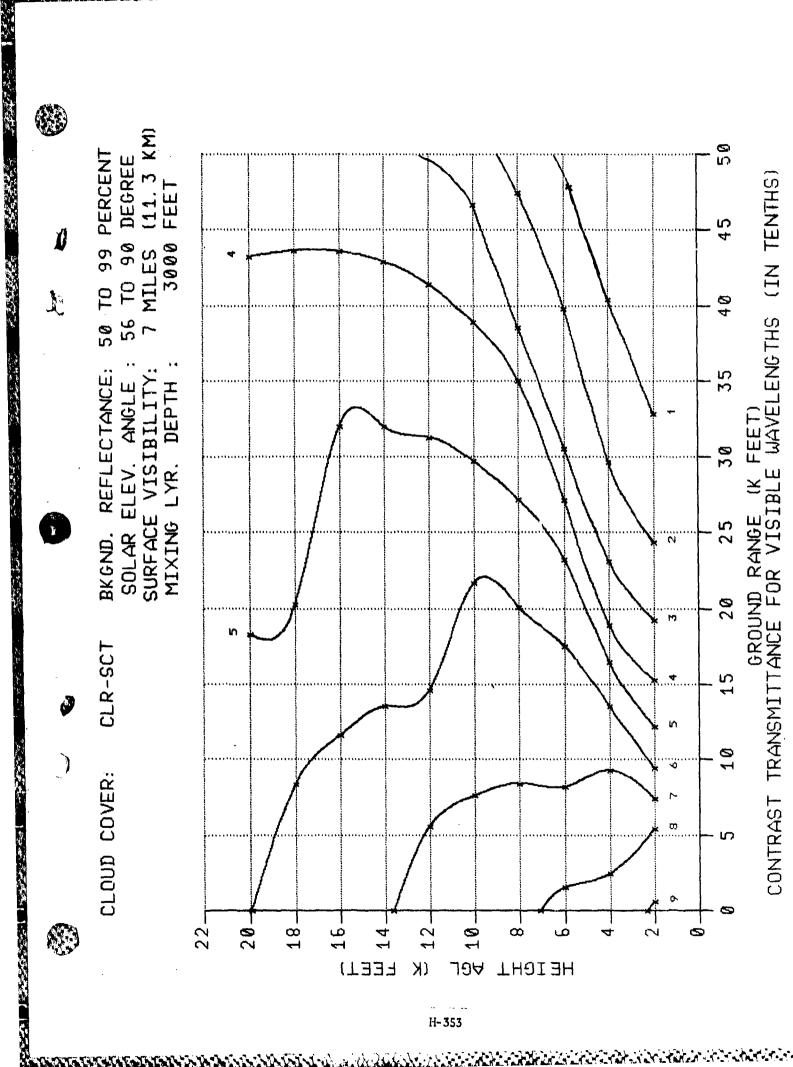


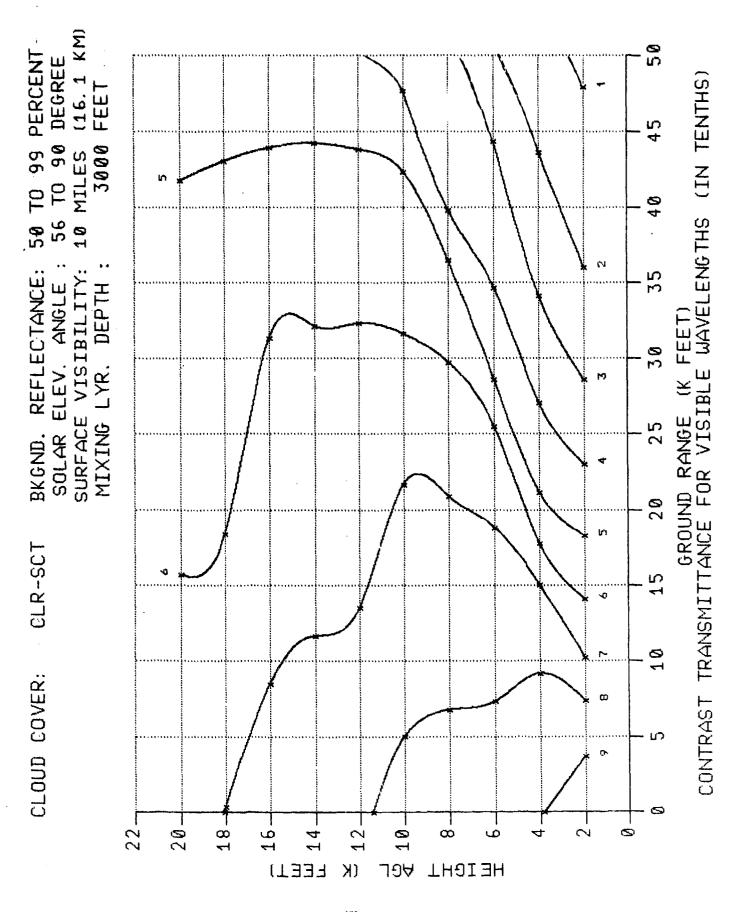


H-351



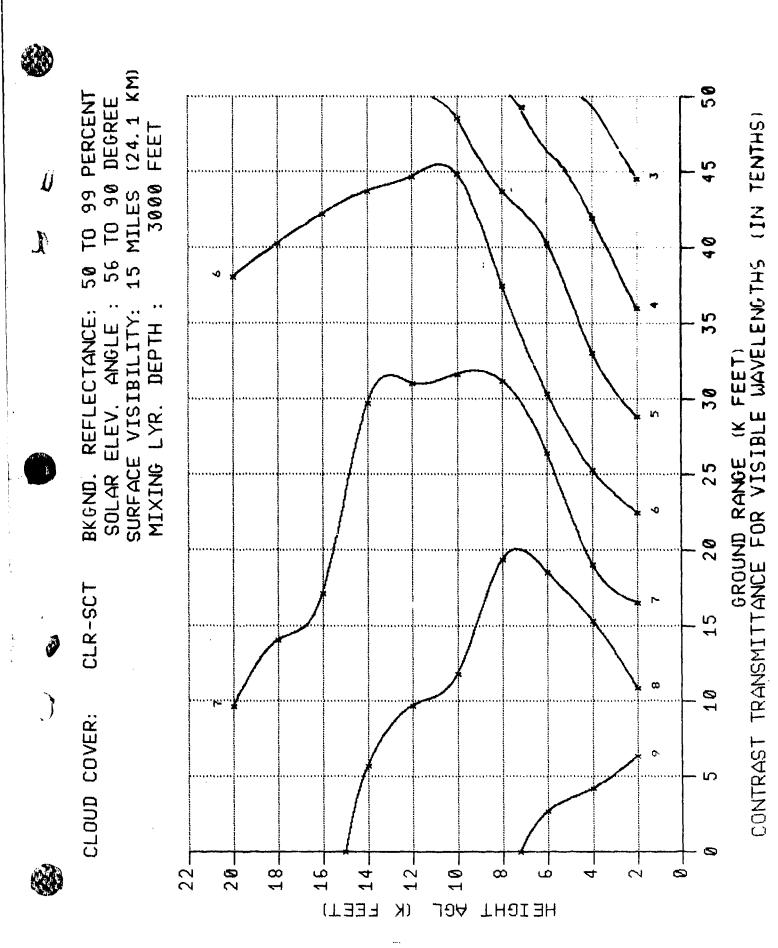
H-352



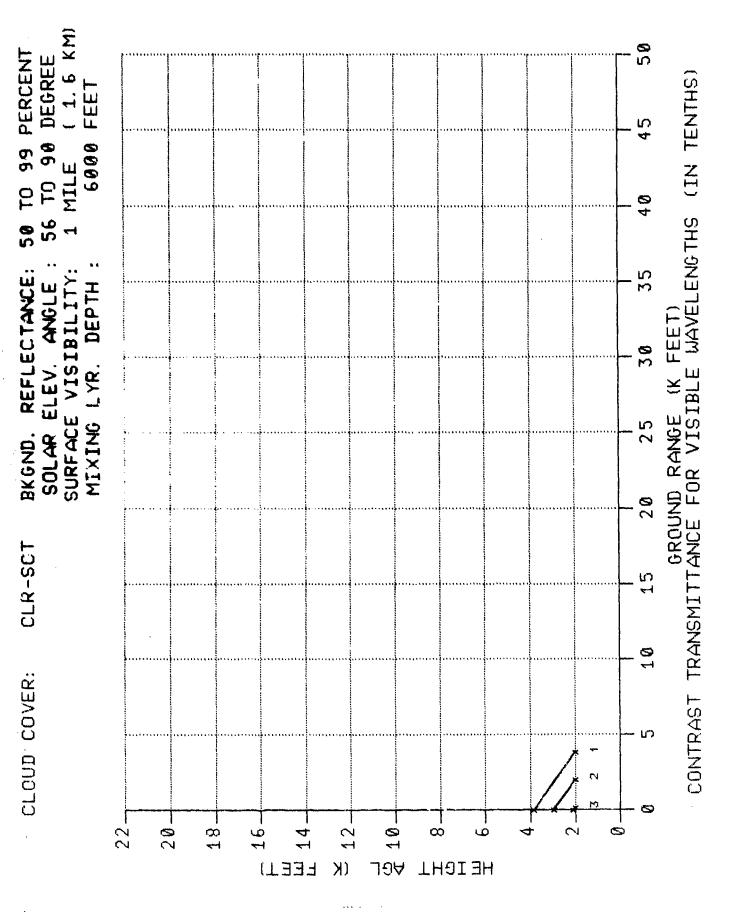


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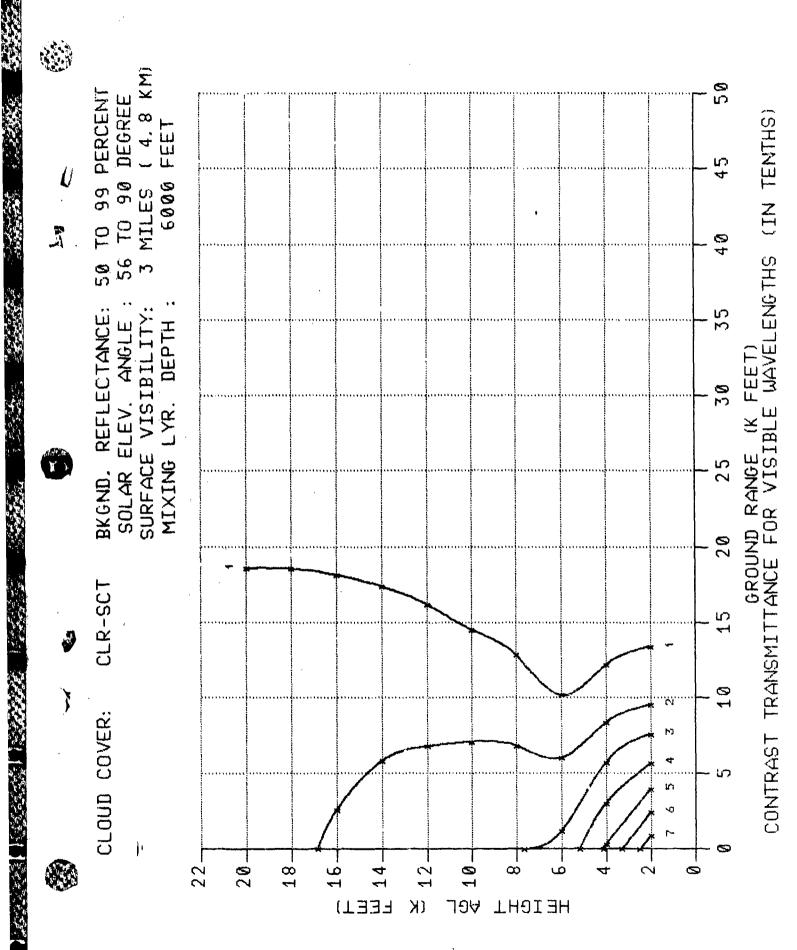
H-355

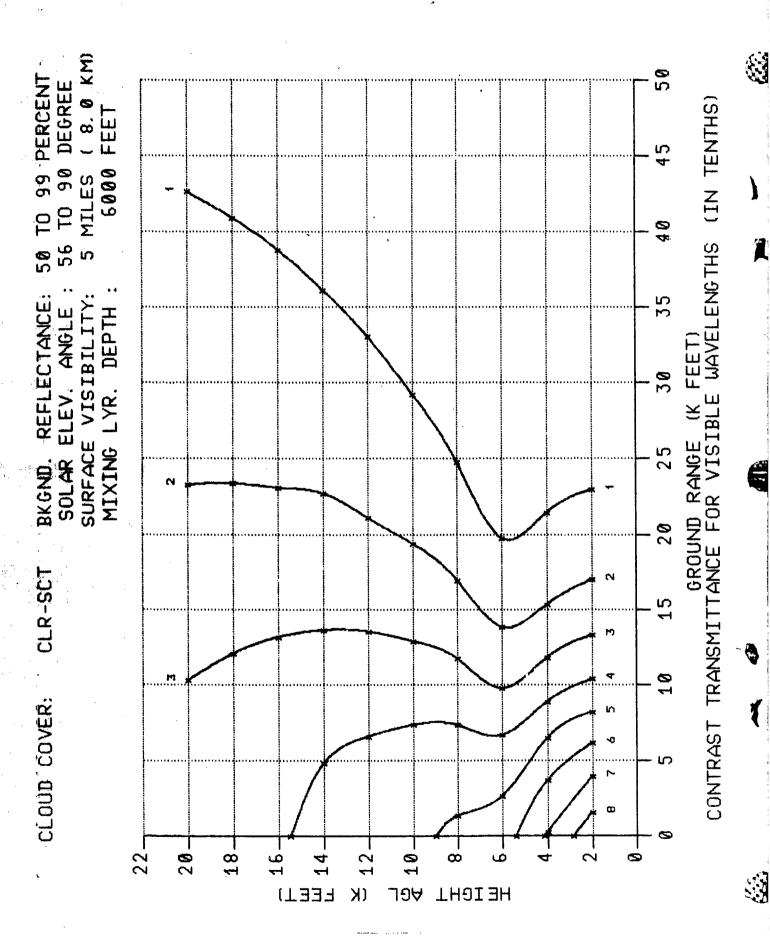


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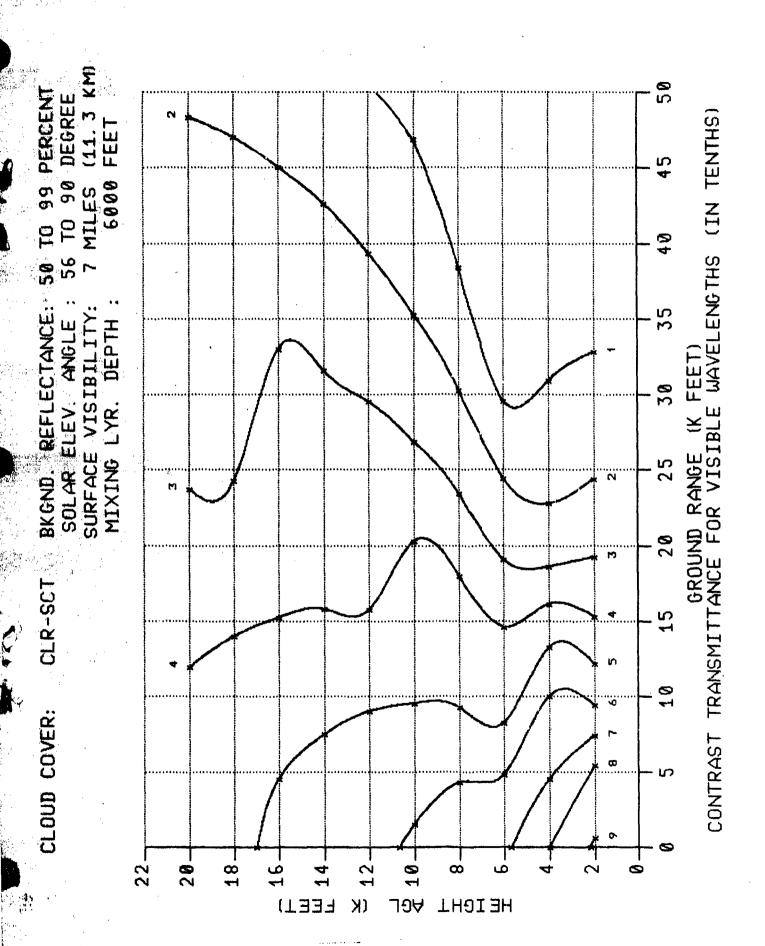
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H-359

 $\Sigma$ 50 99 PERCENT 90 DEGREE (16, 1 GROUND RANGE (K FEET) CONTRAST TRANSMITTANCE FOR VISIBLE WAVELENGTHS (IN TENTHS) FEET 6000 10 MILES 26 35 REFLECTANCE: SURFACE VISIBILITY: MIXING LYR. DEPTH SOLAR ELEV. ANGLE 30 BK GND. CLR-SCT CLOUD' COVER: 8 22\_ 20-10-9 187 16-وٰ 14 12. (LEET) (K 79∀ HE ICHT

H-360

# SUPPLEMENTARY

## INFORMATION



### AD NUMBER

#### AD-B082 564

### NEW LIMITATION CHANGE

TO

DISTRIBUTION STATEMENT - C

Distribution authorized to U.S. Gov't agencies

and their contractors

LIMITATION CODE: 2

FROM DISTRIBUTION STATEMENT - B

LIMITATION CODE: 3

#### **AUTHORITY**

James S. Perkins, DAF, AFWA STINFO, via DTIC FM 55, CNTRL NO 8071011, 16 Mar 1998.

### THIS PAGE IS UNCLASSIFIED

ERRATA DTIC CONTROL NO.

#### REQUEST FOR LIMITED DOCUMENT

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USER'S MANUAL M. D. ;C.AUBER	The following data elements will be printed in the Report Number Contract Number and Corporate August FOR ESTIMATING TARGET ACQUIST, C. J.; REGAN, D. P.; COX, R.: /TN-83/004 AIR FORCE ENVIS	SITION RANGE No. ; COMPTON,	WHEN EM K. J. ;	PLOYING TV DEC, 19	SENSORS. 83 SBI A	Series ABEL, D-E850 COTT
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REQUESTING ORGANIZATION AND ADDRESS SYSTEM PLANNING CORP ATTN: MGR TECH LIB P W MOON		GOVERNMENT SPO	TITLE NAME RESEARCHER MOON			
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SIGNATURE



#### DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AIR FORCE WEATHER AGENCY SCOTT AIR FORCE BASE, ILLINOIS

16 NAR 98

MEMORANDUM FOR DTIC-OCD

ATTN: Mr. Bush

FROM: AFWA Scientific and Technical Information Officer (STINFO)

c/o AFCCC/DOL 859 Buchanan Street Scott AFB IL 62225-5116

SUBJECT: Change of Distribution Statement on USAFETAC/TN-83-/004

- 1. We have received a request (DTIC Control #8071011) for a copy of USAFETAC/TN-83/004 "User's Manual for Estimating Target Acquisition Range When Employing TV Sensors" for a DoD contractor. The technical note was originally limited in distribution to U.S government agencies only. In 1990, the Air Weather Service STINFO reviewed and delimited that technical note, making it "Cleared for Public Release." I can find no correspondence indicating we told you that before, so please update your records accordingly.
- 2. I have sent a paper copy of the delimited tech note directly to the contractor making the request. If you have any questions, I'm at DSN 576-4044.

JAMES S. PERKINS, DAF

AFWA STINFO

cc: DTIC-BCS with DTIC Fm 55

Completul
15 may 2000

\* ADB \$82564

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